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AGRICULTURAL INVESTIGATIONS AT THE UNITED STATES FIELD STATION, SACATON, ARIZ., 1922, 1923, AND 1924[1]

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INTRODUCTION

The function of the United States Field Station[2] at Sacaton, Ariz., is the study of agricultural problems of the Southwestern States, with special reference to those crops and plants which have possibilities of value to the Indians of the Gila River Reservation. The station was established in 1907 through a cooperative arrangement between the Office of Indian Affairs of the United States Department of the Interior and the Bureau of Plant Industry of the United States Department of Agriculture.

The seed farm was established in 1917 for the purpose of providing adequate supplies of pure seed of the new and improved strains of crop plants originated or developed at the United States Field Station for distribution to the Indians on the reservation.

The administration of funds has been largely under the direction of the Indian office at Sacaton, and the supervision of investigations in recent years has been in charge of the Office of Cotton, Rubber, and Other Tropical Plants, of the Bureau of Plant Industry.

[1] In cooperation with the Pima Indian superintendency, Office of Indian Affairs, United States Department of the Interior.
[2] Formerly known as the Cooperative Testing Station.

However, the experimental work from the beginning has been conducted on a cooperative basis between different offices of the Bureau of Plant Industry, especially the Office of Crop Physiology and Breeding and the Office of Alkali and Drought Resistant Crops.

The investigations in recent years included breeding and selection of crop plants, variety tests, cultural methods, time and rate of

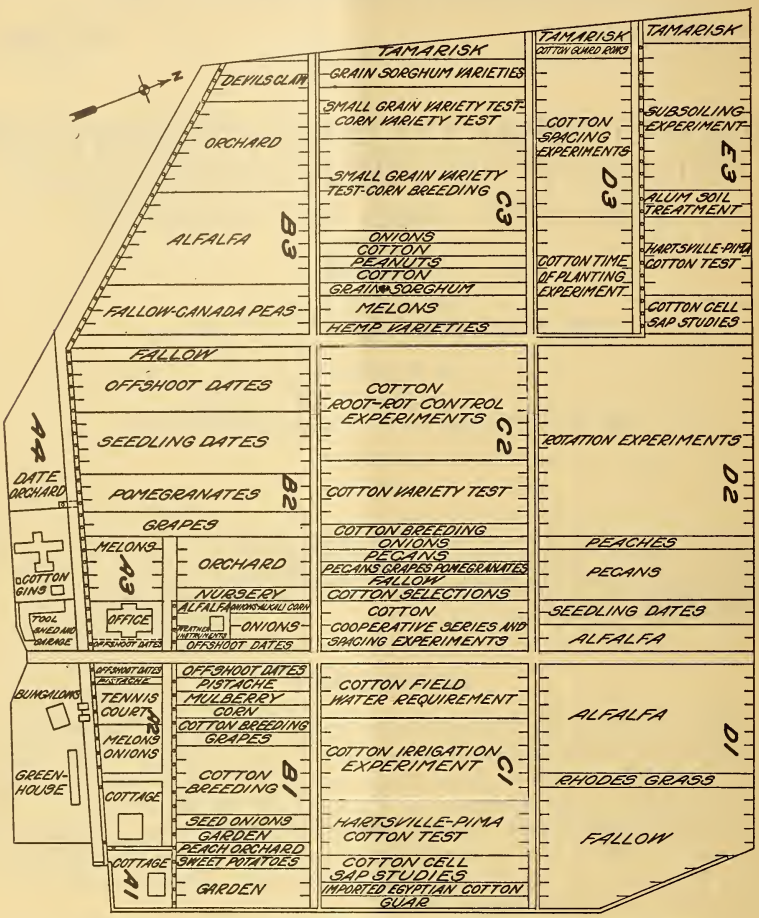

FIG. 1.—Diagram of the United States Field Station, Sacaton, Ariz., showing the arrangement of fields and the location of experiments in 1922

seeding tests, water-requirement studies, methods of root-rot and alkali control, crop-rotation tests, adaptation of exotic plants, and cotton-ginning experiments. Some of the experiments begun in past years, the progress of which has been reported in a previous publication,[3] were continued during 1922 to 1924. The field station has also cooperated with local cotton organizations in maintaining the purity of the Pima Egyptian cotton-seed stock in the Salt River Valley.

[3] King, C. J. Crop tests at the cooperative testing station, Sacaton, Ariz. U. S. Dept. Agr., Dept Circ. 277, 40 pp., illus. 1923.

The purpose of this circular is to give the results of such experiments as are sufficiently complete to be of value to the local farmers and the Indians of the Gila River Reservation and to report the progress of incomplete tests which may be of economic interest to farmers or of scientific interest to investigators.

The location of buildings and the arrangement of crop experiments at the field station for the years 1922, 1923, and 1924 are shown in Figures 1 to 3.

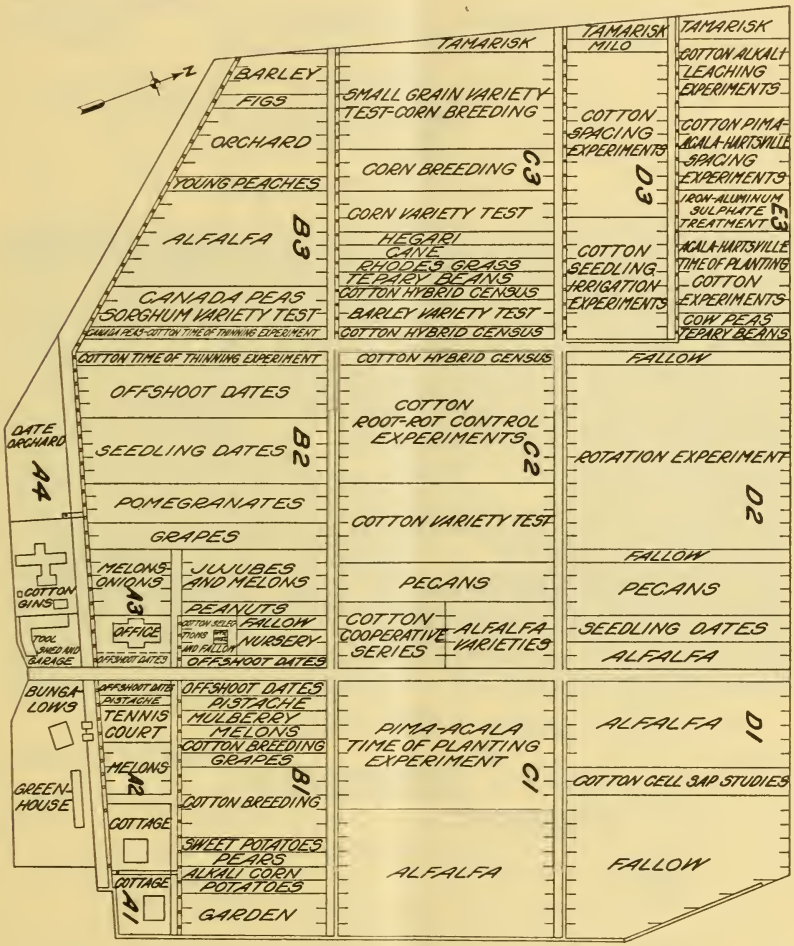

FIG. 2.—Diagram of the United States Field Station, Sacaton, Ariz., showing the arrangement of fields and the location of experiments in 1923

AGRICULTURAL CONDITIONS AMONG THE PIMA INDIANS

The Pima Indians, who live on the Gila River Reservation, in Pinal and Maricopa Counties, Ariz., have been an agricultural people as far back as history records and their own traditions extend. When first visited by the Spanish missionaries in the sixteenth century they were in their present location, practically all of them

engaged in agricultural pursuits under a more or less extensive irrigation system. The records of the War Department show that in 1862 they sold about 1,000,000 pounds of wheat to the Government for the use of the troops operating in that territory.

At the present time the Pimas number about 5,000 and still depend largely on their agriculture. The limited rainfall and the extremely hot and dry summers do not permit crops to be grown without irriga-

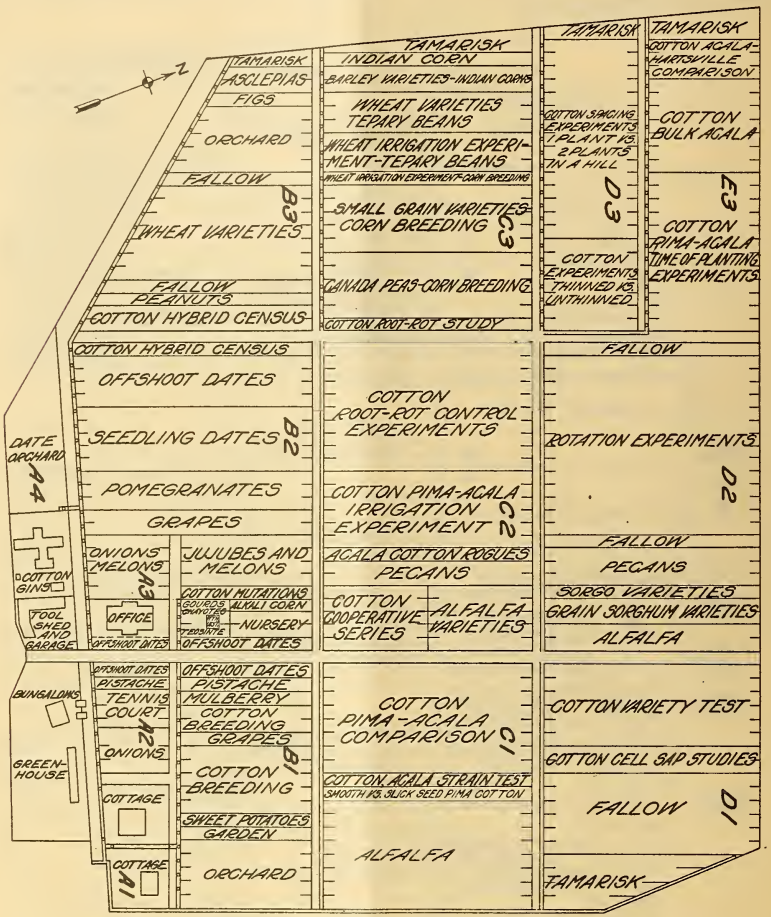

FIG. 3.—Diagram of the United States Field Station, Sacaton, Ariz., showing the arrangement of fields and the location of experiments in 1924

tion in this region, and the Indians have long depended upon the waters of the Gila River for flooding their lands. In recent years there have been extensive land developments by white settlers on all sides of the reservation, and keen competition for obtaining prior right on any available irrigation water has resulted from the successful example of the Salt River Valley and other irrigation projects of that region. As a consequence of this competition and with extensive agricultural developments and denudation of grazing ranges along the

upper reaches of the Gila, the flow of the river is becoming less reliable for the farming operations of the Pimas, and crop failures from drought are of frequent occurrence on parts of the reservation which were once almost constantly productive. Of the 15,826 acres of supposedly irrigable land allotted to the Indians, only 8,965 acres were in crops in 1923 on account of water shortage.

Since wheat can be grown during the winter months when the largest quantity of water can be conserved, this has long been the principal crop of the Pimas. In 1919 more than 25 carloads of wheat were sold by the Indians in addition to the quantity they consumed. In 1922 the value of the Indian wheat crop was estimated at $84,780. The crop in 1924 was estimated at $79,378.

Cotton is of next importance to the Indians and is their leading money crop. One Pima farmer in 1919 secured a return of nearly $4,000 from 60 acres of Pima Egyptian cotton. The scarcity of water at the time when the cotton crop is in greatest need of irrigation,

FIG. 4.—Exhibit of Pima Indian agricultural products at the Arizona State Fair in 1923

however, prohibits any material increase in the area devoted to this crop. The acreage is now largely confined to land that is regularly supplied with water from pumps in addition to the flow of the river.

The area planted to cotton on the reservation in 1922 was 1,697 acres, and the value of the crop was estimated at $63,600. In 1923 there were 1,920 acres in cotton with an estimated value of $96,000, and in 1924 1,611 acres produced a crop valued at approximately $117,600.

Corn ranks third in importance as a field crop for the Indians, followed by alfalfa, barley, milo, and beans, mentioned in the order of their importance. The total estimated value of all Indian crops was $255,362 in 1922 and $255,814 in 1923.

Although some of the more progressive Indians have learned to handle cotton, wheat, corn, and other crops in a very competent way (fig. 4), the greater part of the Indian farming operations on the reservation under the present water-supply conditions are extremely hazardous.

In July, 1924, Congress authorized the construction of a storage dam in the Gila River with the view of alleviating the condition of the Pima people and to compensate them in some measure for the water of which they have been deprived in past years by the white settlers. Officials of the Office of Indian Affairs have already begun the preliminary work for the construction of this reservoir, and it is believed that in a few years the Indians of the Gila River Reservation will begin to share in the prosperity enjoyed by their white neighbors on other irrigated projects.

COTTON PROBLEMS OF THE SALT RIVER VALLEY

The work of the field station has dealt not only with problems of Indian agriculture but with the problems that have special reference to the agriculture in the neighboring valleys, especially the Pima cotton industry in the Salt River Valley, which owes its early development to the work of the field station, where the variety originated.

From 1912, which marked the beginning of the cotton industry in Arizona, until the season of 1921 the Salt River Valley was maintained and recognized as a one-variety cotton community. The Yuma variety of Egyptian cotton which was grown in the valley during the first years of the industry was replaced by the superior Pima variety in 1916, and thereafter only Pima was grown. In 1921 some five or six small areas in different localities in the valley were planted by farmers to upland varieties for purposes of demonstrating their behavior and to sell seed. Considerable agitation was started in 1922 by a few growers and seed dealers to obtain seed of the upland varieties for general planting. The marketing situation favored such propaganda, since the American Egyptian crop was in competition with large importations from Egypt, while the limited stocks of shorter staples caused the prices for these to rise until they were almost equal to those for Egyptian cotton.

Another factor which played a part in reducing the price differential between the two types of cotton was the discovery that certain types of upland cotton could be substituted for the longer Egyptian staples in the manufacture of cord automobile tires. Then, too, on account of the general business depression, the style demand changed from textiles of the more expensive weaves made from long-staple cotton to the more economical textiles which are usually made from short cotton. Considerable difficulty was encountered in obtaining upland seed for planting, and only 4,300 acres of upland cotton were grown and 73,000 acres of Pima. The average yields per acre were not greatly different for the two types in 1922, about 218 pounds of lint per acre being produced by Pima and 238 pounds by upland varieties.

At the beginning of the season of 1923 the condition of the cotton market gave little encouragement for producers of Pima Egyptian cotton, while the prices of short staples were maintained at comparatively high levels. Consequently, the area planted to Pima in the Salt River Valley in 1923 was only about 43,000 acres, whereas about 60,000 acres were planted to upland varieties, the Acala variety predominating. The season of 1923 was extremely favorable for the production of all kinds of cotton in the Salt River Valley. Comparatively cool weather prevailed throughout the month of June,

and there were no extreme fluctuations or torrid conditions of long duration at any time during the summer. Consequently the loss from abortion of buds and bolls was less than usual, and exceptionally high yields resulted. Various estimates place the average yield of upland varieties at 390 to 490 pounds of lint per acre and that of Pima from 308 to 350 pounds. Exceptional prices were maintained throughout the harvesting season, and good profits were generally realized by the growers.

In 1924 the land planted to upland varieties comprised about 110,000 acres, and the Pima variety occupied about 8,000 acres. Shedding of buds and young bolls from upland varieties was unusually prevalent during the middle of the summer, and the yield for the season was lower than usual. The yield of Pima was also smaller than the previous year, but the growers did not attribute this to excessive shedding. The best estimates place the average yield of upland varieties at about 260 pounds per acre and the average yield of Pima at 270 pounds. The average price obtained during the picking season for Pima was approximately 48 cents per pound and for upland 23 cents. At the beginning of 1925 there were indications that about 40 per cent of the total cotton acreage would be planted to Pima.

CLIMATIC CONDITIONS

The climatic conditions at Sacaton during 1922, 1923, and 1924 varied to a slight extent from the average for the previous 12 years in which meteorological records were kept at the field station. It will be noted from the data in Table 1 that the summer temperatures in 1922 were slightly higher than usual. During the latter part of the summer there occurred a protracted rainy period when relatively high temperatures and high humidities prevailed. These conditions, while not adverse to most of the field crops, caused an extremely luxuriant vegetative growth in cotton plants, resulting in an unusually high rate of shedding of squares and bolls. The total annual rainfall in 1922 was somewhat below the average for 15 years, most of the precipitation occurring in the latter part of the summer. No protracted periods of extremely low temperatures occurred during the winter of 1922–23. The lowest temperature recorded was 20° F., which occurred on one night in January and prevailed for only a short time. Little damage was done to fruit trees or other economic plants.

During 1923 the weather conditions were very different from those of the previous year. Much of the summer and early fall was characterized by considerably lower temperatures than are shown by the 15-year average, the monthly means of maximum and minimum temperatures having been from 2 to 5 degrees lower. The growing season was particularly favorable for cotton, as the plants were not subjected to any unusual stress conditions occasioned by excessive heat and high humidity. The total rainfall exceeded the annual average for 15 years by more than 2 inches, there having been unusually heavy precipitation during November and December.

The year 1924 was characterized by extreme dryness and somewhat higher temperatures during the summer months. The total annual rainfall was nearly 4½ inches less than that for the 15-year average. The summer was continuously warm without the cooler intervals which accompany the usual rains. Crop conditions were favorable

on the whole, except for cotton, which suffered to some extent from the uninterrupted high temperatures.

The meteorological data for 1922, 1923, and 1924 and the average of the data obtained for the 15 years from 1910 to 1924, inclusive, are summarized in Table 1.

TABLE 1.—*Summary of meteorological records at the United States Field Station, Sacaton, Ariz., showing the 15-year average from 1910 to 1924, inclusive, compared with the years 1922, 1923, and 1924*

MEAN TEMPERATURE (° F.)

Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
15-year average	50.5	54.2	59.5	65.4	73.5	83.5	87.6	87.0	81.5	69.0	58.1	50.1	------
1922	46.9	53.1	54.5	61.2	74.8	84.8	88.8	87.3	82.8	70.5	52.8	52.5	------
1923	52.9	53.7	65.4	65.2	75.5	79.3	86.9	84.7	78.0	64.1	57.1	50.9	------
1924	47.7	55.2	54.8	62.9	76.3	84.6	87.8	88.9	82.2	67.6	58.6	48.5	------

MEAN MAXIMUM TEMPERATURE (° F.)

15-year average	66.1	70.5	76.0	83.1	92.6	102.6	102.1	101.3	98.1	87.2	76.0	66.0	------
1922	62.3	68.3	70.4	78.3	94.0	103.6	102.6	101.1	98.2	88.3	71.0	67.1	------
1923	70.1	67.9	72.4	81.8	95.0	99.8	100.2	96.9	94.7	82.3	69.3	61.2	------
1924	64.7	73.8	70.1	80.0	94.8	103.7	102.0	103.6	99.0	87.0	78.6	62.9	------

MEAN MINIMUM TEMPERATURE (° F.)

15-year average	34.5	37.6	41.7	47.7	54.5	64.3	73.1	71.8	64.9	50.8	40.1	34.3	------
1922	31.6	37.9	38.6	44.1	55.5	66.0	75.0	73.5	67.3	52.6	34.6	37.8	------
1923	35.7	39.5	40.3	48.6	56.1	58.7	73.6	72.5	61.3	45.8	44.9	40.5	------
1924	30.6	36.5	39.4	45.9	57.9	65.5	73.6	71.8	65.5	48.1	38.7	34.1	------

RAINFALL (INCHES)

15-year average	1.02	0.59	0.89	0.32	0.25	0.14	1.87	1.29	0.64	0.51	0.95	1.41	9.89
1922	1.11	.41	1.23	.78	.22	.11	.53	3.32	.55	------	1.20	.26	9.72
1923	.67	.64	.81	.16	.31	------	3.27	.97	.01	.24	2.36	3.25	12.69
1924	------	------	1.33	.25	.51	------	.39	.20	.40	.49	------	1.85	5.42

EVAPORATION (INCHES)

7-year average	2.231	2.647	4.386	5.889	8.025	8.702	7.854	7.053	6.312	4.358	2.832	2.104	62.393
1922	2.162	2.382	4.086	5.820	7.484	9.624	9.611	8.081	6.635	5.002	2.767	1.666	65.320
1923	2.310	2.746	4.516	5.948	------	8.881	7.309	5.967	6.853	4.853	2.568	1.734	------
1924	2.151	3.195	4.357	5.599	8.782	9.544	8.012	7.981	6.063	4.652	2.914	2.062	65.312

DAILY WIND VELOCITY (MILES PER HOUR)

Maximum:													
1922	4.4	5.3	4.1	5.2	5.8	3.1	3.4	2.3	2.8	2.4	2.5	1.6	------
1923	6.0	4.2	5.5	5.4	3.9	3.7	3.0	1.8	4.0	3.4	3.2	3.4	------
1924	5.6	3.7	4.1	6.4	4.5	4.6	2.7	2.2	3.6	4.7	5.3	4.1	------
Minimum:													
1922	.8	1.0	.9	1.4	1.1	1.0	1.0	.8	.6	.7	.8	.4	------
1923	.8	.8	.8	1.0	.9	1.2	.7	.4	.4	.6	.2	.6	------
1924	.5	1.0	1.2	1.0	1.6	1.0	.8	1.0	1.0	.9	.7	.8	------
Averages:													
7-year average	1.9	2.1	2.2	2.4	2.1	1.8	1.6	1.3	1.4	1.4	1.6	1.6	------
1922	1.8	2.1	2.3	2.6	1.9	1.8	1.8	1.3	1.1	1.3	1.3	1.1	------
1923	1.7	2.1	2.5	2.2	1.7	1.8	1.4	.9	1.0	1.1	1.2	1.3	------
1924	1.5	1.8	2.0	2.4	2.2	2.2	1.8	1.6	1.7	1.6	1.4	1.8	------

SOIL-IMPROVEMENT EXPERIMENTS

EXPERIMENTS IN COTTON ROOT-ROT CONTROL

The disease commonly called Texas root-rot is prevalent in many parts of Arizona, but especially along the Gila River, which it appears to follow across the entire State, causing serious losses to cotton, alfalfa, and numerous tree crops in the counties of Greenlee, Graham, Pinal, Maricopa, and Yuma. Its presence on certain parts of the grounds of the field station, which is located only a short distance from the Gila River, has been the source of much annoyance and considerable loss of plant material since the beginning of the experimental work in 1907.

Experiments were begun in 1920 in an effort to find some means of controlling the disease in cotton and alfalfa. The negative results of some of these tests and the progress of others were reported in a publication of 1921,[4] at which time none of the methods in use showed any very striking indications of being effective. The results during the seasons of 1922, 1923, and 1924 indicate the efficacy of organic manures and formaldehyde as agencies of control. The effect of manure was tested for the first time on plat C2–19 in the winter of 1920–21. The manure was applied at the rate of 12 tons per acre in wide furrows, after which the land was leveled and the cotton planted in rows directly over the buried organic material. In 1922, 1923, and 1924 the experiment was extended to include nine plats, three of which received barnyard manure and one received alfalfa hay, applied each year as above described. The other plats occurring alternately between those treated were used as controls. The results as shown from the extent of infected area in the treated plats, compared with those not treated, are given in Table 2.

TABLE 2.—*Percentage of area infected with root-rot in plats of Pima cotton manured and unmanured at the United States Field Station, Sacaton, Ariz., from 1919 to 1924, inclusive*

[The asterisk (*) indicates that the plat was manured prior to planting]

Plat	1919	1920	1921	1922	1923	1924	Plat	1919	1920	1921	1922	1923	1924
C2-24	------	------	------	14.5	38.4	70.9	C2-19	57.1	71.7	*13.8	*14.1	*3.7	*2.2
C2-23	43.0	63.0	55.4	51.6	*9.7	*10.2	C2-18	------	77.3	46.4	65.3	24.1	22.9
C2-22	68.9	65.3	20.9	60.8	29.7	22.4	C2-17	51.3	61.9	51.8	65.6	*11.8	*7.4
C2-21	60.4	70.6	37.9	56.6	*14.6	*14.4	C2-16	------	39.4	36.8	53.8	9.2	16.2
C2-20	49.5	47.3	14.6	27.1	15.0	11.6							

On account of the erratic behavior of the root-rot disease, it is difficult to interpret the results obtained from control experiments conducted in the field. The data in Table 2 seem to indicate, however, that the applications of organic material were effective in reducing the extent of the infected area and in maintaining this reduction during ensuing years.

Tests made at the field station in the summer of 1922 demonstrated that small isolated areas of root-rot infection could be controlled by saturating the infected soil with formaldehyde (1 to 100 solution).[5] In 1923 an effort was made to exterminate the disease organism in

[4] See footnote 3

[5] C. J. King. Cotton root-rot in Arizona. *In* Jour. Agr. Research, vol. 23, pp. 525–527. 1923.

a badly infected area one-seventeenth of an acre in extent by the same means before planting. This area, on which 92 per cent of the cotton plants had died of root-rot in 1922, was separated from the infected plats on either side by walling in the soil to a depth of 3½ feet with boards. The soil was then irrigated with a 1 to 100 formaldehyde solution applied from a street-sprinkling tank. The solution of this strength failed to penetrate to the 3½-foot depth desired, and as soon as all of it had been absorbed by the soil irrigation water was applied at the rate of 2 acre-inches. The cottonseed was planted five days later. Several small spots of infection appeared in the cotton on the treated area during the season, but the entire area infected at the end of the season amounted to only 6.9 per cent.

In 1924 the experiment was repeated on a spot about one-twentieth of an acre in area which had been severely infected the previous year. In spite of the precautions which were taken to obtain deep penetration of the solution and to segregate the disinfected area, two centers of infection appeared late in the season and several plants were killed. The method seems to offer little hope as a control measure except where small isolated spots of infection occur on a valuable piece of land.

TREATMENT WITH ALUMINUM SULPHATE

The soil at the seed farm, which is a coarse sandy loam, is for the most part readily permeable to irrigation water. There are, however, small areas known locally as "slick spots" in which colloidal substances prevent the free passage of water. These spots are made conspicuous by the effect on the crops grown upon them. Plants growing on such spots make a slower growth and wilt much more quickly than those on the more permeable soil. Results obtained in laboratory tests indicated that this condition might be remedied by the application of aluminum sulphate. Field experiments were therefore begun in 1923 in cooperation with the Office of Western Irrigation Agriculture of the Bureau of Plant Industry to determine the effect of such applications.

A plat of 75 square feet in which the penetration of water was very poor was selected. It had been noted that crop plants on this plat had frequently suffered from lack of moisture. A near-by tract of more permeable land was used as a check. Both areas were irrigated, and 48 hours later samples of soil to a depth of 3 feet were taken. It was found that water had penetrated to a depth of but 12 to 14 inches on the "slick" or impermeable tract whereas in the check area it had reached more than twice that depth. Aluminum sulphate at the rate of 5 tons per acre was then applied to the "slick" area, and both plats were immediately covered with water to a depth of 2 inches. Moisture determinations made on soil samples taken the following day failed to show water penetration in the treated plat below the second foot, so 4 inches more of water were applied to both plats. After this irrigation there was a marked increase in the penetrability and softening of the soil in the treated plat. Percolation tests carried on with soil samples in the laboratory showed that as a result of the treatment the leaching rate had been increased two to three times in the surface 3 feet of soil.

This experiment was repeated about a month later on the same areas of soil, another application of aluminum sulphate at the same rate per acre being given. The difference between the two areas, as

shown in the laboratory leaching test, was not so great as after the first application; but moisture determinations showed an appreciable increase in water content after treatment, particularly in the surface foot of soil.

From these experiments it seems apparent that the application of aluminum sulphate in sufficient quantities to the so-called "slick" spots in soils of the seed-farm type materially increases their permeability and friability.

COMPARISON OF FERTILIZERS

A fertilizer experiment, at the seed farm, in which various combinations of the three principal plant-food constituents were used on cotton, was begun in 1921 and repeated in 1922, the same land being used in both years. This was a duplicate of an experiment conducted by the University of Arizona at the State Experiment Farm at Mesa, Ariz. Table 3 shows that no material increases in yield resulted from these applications in either year. It seems apparent from the negative results obtained from these experiments and from the generally improved crops at the seed farm following alfalfa that such soils require the addition of humus-building materials rather than mineral fertilizers for increasing their productivity.

TABLE 3.—*Yield of seed cotton per acre in a comparison of fertilizers at the seed farm, Sacaton, Ariz., in 1921 and 1922*

Plat	Fertilizer applied on an acre basis	Acre yields (pounds)	
		1921	1922
No. 1	5 tons of barnyard manure	1,030	512
No. 2	Check, no treatment	1,035	575
No. 3	10 tons of barnyard manure	1,030	625
No. 4	10 tons of barnyard manure and 300 pounds of acid phosphate	1,260	912
No. 5	250 pounds of acid phosphate	1,090	781
No. 6	Check, no treatment	1,236	1,050
No. 7	500 pounds of acid phosphate	1,000	1,025
No. 8	500 pounds of acid phosphate and 200 pounds of nitrate of soda [1]	1,327	875
No. 9	500 pounds of acid phosphate and 450 pounds of cottonseed meal	1,084	662
No. 10	Check, no treatment	1,266	931
No. 11	500 pounds of acid phosphate, 200 pounds of nitrate of soda,[1] and 150 pounds of potash.	1,224	775
No. 12	200 pounds of nitrate of soda [1]	1,151	931
No. 13	600 pounds of nitrate of soda [1]	1,054	860
No. 14	Check, no treatment	1,296	1,131
No. 15	700 pounds of cottonseed meal	1,308	847
No. 16	300 pounds of commercial fertilizer	1,400	1,162
Average yield on adjoining cotton acreage		1,353	1,162

[1] Nitrate of soda in two applications, one half just before planting and the other half just after thinning.

COTTON EXPERIMENTS

VARIETY TESTS

Although the principal work of the field station has been devoted to the breeding and cultural improvement of Pima Egyptian cotton (fig. 5), the commercially important upland varieties also have been tested. Those varieties which appear best adapted to southwestern conditions have received special study during recent years when marketing conditions have been comparatively unfavorable for Egyptian cotton. Small plantings of several upland varieties were made for purposes of study and comparison prior to 1920, but beginning in

that year tests have been conducted with the most promising varieties on such scale as to obtain data as to their comparative yields. In 1920 the test comprised only three varieties—Pima, Durango, and Lone Star. In 1921 Acala was added, a variety of Mexican origin, which was then a local favorite in Oklahoma and northern Texas and has now attained almost general popularity over a considerable part of the Cotton Belt of the United States.

In 1922 the tests were continued, with the addition of Hartsville, a variety originated by the United States Department of Agriculture, and developed by the Coker seed farm at Hartsville, S. C. It was distributed about 1911 but did not obtain popularity in the Southeast on account of being too late under boll-weevil conditions. The seed of this variety, contributed by a dealer in the Salt River Valley, was of inferior quality and the resulting stand was so poor that the yield

FIG. 5.—Pima Indian women picking Pima Egyptian cotton, a variety developed at the United States Field Station, Sacaton, Ariz.

of 934 pounds of seed cotton per acre was not considered comparable and was not included in the test for that year. In 1923 and 1924 Hartsville was included and also Mebane Triumph. An excellent stand resulted from all plantings in both years. The acre yields of seed cotton for each variety during the 5-year period are shown in Table 4.

TABLE 4.—*Yields of seed cotton obtained from varieties grown for comparison at the United States Field Station, Sacaton, Ariz., 1920 to 1924, inclusive*

Variety	Acre yields (pounds)					Average	
	1920	1921	1922	1923	1924	For five years, 1920 to 1924	For four years, 1921 to 1924
Pima	1,826	1,996	2,050	2,367	2,033	2,054	2,112
Hartsville				2,307	828		
Durango	1,441	769	1,544	2,311	814	1,376	1,360
Acala		1,914	1,647	2,406	1,053		1,755
Lone Star	1,764	1,837	1,414	2,357	676	1,610	1,571
Mebane				2,390	793		

The opinion is held by most of the cotton growers in Arizona that any of the commercially important upland varieties in the Southwest will outyield the Pima Egyptian variety when grown under comparable conditions. The yields of the six varieties shown in Table 4 will no doubt be surprising to those who hold the opinion that in growing long-staple cotton there must necessarily be a sacrifice in the quantity produced as compared with short-staple yields. It will be seen that Pima consistently led all varieties in yield except in 1923, when it was outyielded 39 pounds by Acala and 23 pounds by Mebane, differences which were not significant. In comparing average yields for four and five years, it will be noted that Pima considerably outyielded the other varieties. In the Salt River Valley, however, the average yield for the upland varieties during the years 1922 and 1923 was somewhat greater than for Pima, as shown by several surveys by State officials and cotton organizations.

It was also indicated by several other comparative tests of Pima, Hartsville, and Acala conducted during the years 1922 to 1924 that the upland varieties sometimes outyield Pima at Sacaton. This was especially true for the season of 1923, when Acala outyielded Pima considerably in every comparison except in the test of six varieties, the results of which are shown in Table 4. In every case where the comparative tests were conducted on a soil that is uniform with a high water-holding capacity and exceptionally productive for other crops the Pima variety led all the upland varieties except in the year 1923, when there was little difference between any of the yields. In cases where the tests were conducted on soil that had been in cotton for several years or which contained strata of coarse sand or hard layers that were impervious to water, the advantage appeared to be in favor of the upland varieties.

Aside from these local soil differences, there appear to be other reasons for the apparent divergence in crop behavior between the Salt River Valley and the deep alluvial lands along the Gila River. The opinion is general that the latter are especially well adapted for the production of Pima cotton, in spite of the fact that the growing season is considerably shorter along the river than on the higher levels, as shown by the difference between Sacaton and Phoenix, which is about 26 days.

The other factor which might be considered as affecting one type more than another, especially in relation to the shedding of buds and bolls, is the daily range in temperature. At Phoenix the average daily range for 25 years was observed to be 28 degrees, whereas at Sacaton for 12 years it was found to be 35 degrees.

On account of the interest in Hartsville, which was the first upland variety to receive attention in the Salt River Valley after the establishment of the American Egyptian cotton industry, a more comprehensive test than the above was started in 1922 for the purpose of comparing the Pima and Hartsville varieties. In 1922 Pima and Hartsville were planted alternately on plats of seven rows each, six plats being planted on April 5 on a soil somewhat impervious in character on account of its alkali content and the other four plats on April 7 on a soil somewhat sandy in nature and not highly productive. In 1923 the comparison included four plats planted on April 28 on soil of an impervious character. It will be observed by reference to Table 5 that the difference in the average yields of the two varieties

on the 10 plats grown in 1922 was not material, whereas in 1923 there was a difference of 370 pounds of seed cotton in favor of the Hartsville variety. However, the soil in the plats was so variable that the yields are not significant.

In 1924 a test was conducted on eight quarter-acre plats of seven rows each for the purpose of comparing the yielding qualities of the Pima and Acala varieties when irrigated to meet the needs of each variety. The two varieties were planted on April 8 on alternate blocks, four rows in each plat being planted to one variety and three rows to the other. Effort was made to irrigate four of the plats to meet the water needs of the Pima plants, and the other four received irrigations only when the Acala plants indicated the need of water. The yields of seed cotton computed on an acre basis for the eight plats are given in Table 5.

TABLE 5.—*Comparative yields of seed cotton of the Pima, Hartsville, and Acala varieties planted in alternate blocks at the United States Field Station, Sacaton, Ariz., in 1922, 1923, and 1924*

Plats	Acre yields (pounds)									
	1922		1923		1924					
					Irrigated to suit Pima requirements			Irrigated to suit Acala requirements		
	Pima	Hartsville	Pima	Hartsville	Plat	Pima	Acala	Plat	Pima	Acala
Alternate plantings	1,125	1,147	1,248	1,398	C1–11	1,564	1,707	C1–15	1,358	1,437
	908	1,441	1,030	1,620	C1–12	1,461	1,695	C1–16	1,289	1,307
	1,792	1,325	------	------	C1–13	1,368	1,739	C1–17	1,334	1,317
	1,507	1,364	------	------	C1–14	1,280	1,500	C1–18	1,093	1,426
	987	1,189	------	------						
Average	1,264	1,293	1,139	1,509	--------	1,418	1,660	--------	1,269	1,372

IRRIGATION EXPERIMENTS

Since 1919 an experiment has been conducted on the proper frequencies for applying irrigation water to cotton. This experiment was continued in 1922, the cultural treatment and irrigation being similar to that used in former years. The different treatments in frequency of applying the irrigation water were given the arbitrary terms "normal," "medium heavy," and "heavy." Each treatment was made in duplicate in 1922 instead of in triplicate, as in previous years. There was little difference in the yields in any of the plats, regardless of the treatment. It was indicated from results obtained in former years that the medium-heavy treatment was best adapted for all seasonal conditions in this region. The yields recorded in 1922 offer no contradiction to this conclusion.

An argument advanced by dealers who wished to sell upland cotton seed to the Indians on the reservation was that the upland varieties required much less water than the longer season Egyptian cotton. In 1923 an experiment was conducted for the purpose of determining whether there was a material difference in the field water requirements of Pima Egyptian and Acala upland cottons.

Four one-fourth-acre plats were used in the experiment, alternate plats being planted to Pima and Acala on April 10. An effort was made to give all of the plats approximately the same quantity of water, but two of the plats, one Pima and one Acala, received lighter and more frequent applications than the other two, which more nearly represented the "normal," or commercial, practice of applying 3 or 4 acre-inches at a time. The water was measured by means of rectangular weirs at the head gates, and the moisture absorption by the soil was determined from soil samples taken at frequent intervals. The water measurements were not begun until after the plants were thinned on June 5, and the water used by the crop prior to that date was not taken into account in the measurements. The data are to be given in detail in another publication, but the quantities applied at each irrigation and the yields per acre of seed cotton are given in Table 6.

TABLE 6.—*Application of irrigation water to alternate plats and resulting yields of Pima and Acala cotton at the United States Field Station, Sacaton, Ariz., in 1923*

Date water applied (normal application)	Pima C1-12	Acala C1-13	Date water applied (light, frequent application)	Pima C1-14	Acala C1-15
1923	*Acre-inches*	*Acre-inches*	1923	*Acre-inches*	*Acre-inches*
June 19	4.57	4.32	June 19	3.70	3.70
July 19	3.81	2.55	July 4	3.39	3.14
Aug. 11	4.62	3.58	July 19	1.88	1.88
Aug. 24	2.95	2.95	Aug. 7	1.85	1.85
Sept. 11	2.66	2.66	Aug. 20	2.29	2.16
Oct. 2	3.29	3.29	Sept. 4	2.51	2.51
Oct. 19	2.19	2.19	Sept. 11	2.51	2.51
			Oct. 2	2.34	2.34
			Oct. 19	2.03	2.03
Total	24.09	21.54	Total	22.50	22.12
	Pounds	*Pounds*		*Pounds*	*Pounds*
Acre yields of seed cotton	1,391	2,269	Acre yields of seed cotton	1,420	2,144

In 1924 the same experiments were continued, but the planting was made on a more uniform soil than that used in 1923 and was extended to include one plat each of Pima and Acala on which a "light-frequent" irrigation treatment was begun early in the season. The water was not measured when applied, but the same relative quantity as applied under the "normal" and "light-frequent" treatments in 1923 was approximated. The yields per acre, the irrigation dates, and the quantity of water used during the active fruiting season, as calculated from soil-moisture determinations under the three treatments, are given in Table 7.

Table 7 shows that the highest yields were obtained from the plats which received three irrigations before July 1. The summer of 1924 was unusually dry and hot, and the early irrigations were apparently advantageous in the production of early fruit. The first picking gave a much higher yield of both Pima and Acala under the early-irrigation treatment than under the others, indicating that the fruiting began earlier. However, previous experiments have shown that such advantages from early applications of water may not always be realized, and such applications are not to be advised for exceptionally fertile land.

TABLE 7.—*Yields, quantity of water lost,*[1] *and irrigation treatments of plats of Acala and Pima cotton at the United States Field Station, Sacaton, Ariz., in 1924*

Items of comparison	Irrigation treatment					
	Early light frequent		Light frequent		Normal	
	Acala, C2-9	Pima, C2-10	Acala, C2-13	Pima, C2-14	Acala, C2-11	Pima, C2-12
Acre yields of seed cotton.....pounds	1,880	2,276	1,440	1,800	1,360	2,002
Water lost (calculated)[1].....acre-inches	33.59	36.46	----------	----------	29.82	34.79
Irrigation dates	May 16 June 6 June 20 July 11 July 25 Aug. 1 Aug. 9 Aug. 15 Aug. 26 Sept. 9 Sept. 23		May 30 June 20 July 1 July 18 July 29 Aug. 5 Aug. 12 Aug. 22 Sept. 2 Oct. 3		--------- May 30 --------- July 1 --------- July 25 Aug. 9 --------- Aug. 19 Sept. 2 Sept. 30	

[1] Not determined for the light-frequent treatment.

From the results shown in Tables 6 and 7 it does not appear that the method of applying small quantities of irrigation water at frequent intervals has any advantage over the conventional, or "normal," method after the flowering period has begun and is less economical than the latter in water usage.

It is indicated that the Pima variety requires a little more water for producing a full crop than the Acala, but the difference is not material.

The susceptibility of the yield of upland varieties to the climatic influences of different seasons is illustrated in Tables 6 and 7. The season of 1924 was decidedly unfavorable to the setting of buds and bolls on upland cotton, and although the soil conditions were much more favorable in 1924 than in 1923 the yield of Acala was much less than in 1923, and the yield relations of the two types of cotton were reversed.

SPACING EXPERIMENTS

Although cotton growing has been the leading industry in the Salt River Valley for several years, the question of proper spacing of the cotton plants is still a matter of current interest. Since the upland varieties have taken first place in the acreage planted to cotton, there has arisen a demand for more information in regard to the proper spacing of these varieties under irrigated conditions.

Experiments with Pima cotton have been conducted at the field station since 1918, in order to determine as nearly as possible the optimum space between rows and between plants in the row. A summary of the results for six years is given in Table 8.

The results shown in Table 8 afford evidence that maximum yields of cotton can be produced in this region with the plants crowded close together, provided the quantity of water applied is largely under the control of the grower. In years when there is a heavy rainfall during the fruiting period it sometimes happens that the growth of closely spaced plants can not be controlled on heavy or unusually fertile soils, and the rapid growth causes the loss of a considerable part of the crop. Table 8 shows that the most favorable results

were obtained from the closely spaced planting during years when there was little summer rainfall.

TABLE 8.—*Yields of Pima cotton in spacing experiments at the United States Field Station, Sacaton, Ariz., in stated years*

[The precipitation, in inches, for June, July, and August for each of the six consecutive years was as follows: 1918, 2.92; 1919, 5.39; 1920, 1.60; 1921, 5.67; 1922, 3.96; 1923, 4.24]

Year	Spacing distance (inches)— Between plants	Between rows 30	42	54
Acre yields of seed cotton:		*Pounds*	*Pounds*	*Pounds*
1918	4	3,136	2,169	2,612
1919	4	----	1,577	----
1920	4	2,113	2,070	1,994
1921	4	1,148	1,320	1,354
1922	4	2,167	1,987	1,780
1923	4	1,244	1,520	1,429
1918	8	3,009	2,657	2,355
1921	8	1,348	1,391	1,512
1922	8	1,807	1,889	1,762
1923	8	1,115	1,567	1,041
1918	12	2,596	2,315	2,098
1920	12	1,884	1,839	1,826
1921	12	1,630	1,523	1,570
1922	12	1,826	2,092	1,461
1923	12	1,038	1,184	1,047
1918	16	2,462	2,603	1,977
1921	16	1,320	1,258	1,145
1922	16	1,811	1,866	904
1923	16	805	1,134	1,266
Average for four years, 1918, 1921, 1922, 1923	4	1,924	1,749	1,794
	8	1,820	1,876	1,667
	12	1,772	1,778	1,544
	16	1,599	1,715	1,323

In 1922 a comparison was made between a spacing with two plants together in hills 14 inches apart and one plant with a 1-foot spacing, which is being used by many growers of Egyptian cotton in Arizona instead of the much wider spacing used in former years. The yields resulting from the two systems of spacing are given in Table 9.

TABLE 9.—*Yields of Pima cotton in spacing experiments at the United States Field Station, Sacaton, Ariz., in 1922*

Seed cotton	1 plant to the hill, 1 foot apart	2 plants to the hill, 14 inches apart
Acre yields (pounds)	1,939	2,104
	1,813	2,067
	1,776	----

In 1924 a similar test was conducted with hills of one and two plants each spaced 1 foot apart in the row. Seven plats of seven rows each were planted to Pima cotton on April 15 and eight plats on May 15. At the time of thinning, the two kinds of spacing were left alternately

with four rows of one adjoining three rows of the other in each plat. At picking time the rows on the seven plats planted on April 15 were picked in two sections of 100 feet in length, but no division was made in the plats planted on May 15 on account of the small yield. The mean yields per row of the two spacing methods are given in Table 10.

TABLE 10.—*Yields of Pima seed cotton under spacing systems of two plants and one plant to a hill 12 inches apart at the United States Field Station, Sacaton, Ariz., in 1924*

Planting date	Number of rows	Row length (feet)	Average yield per row (pounds)	
			2 plants per hill	1 plant per hill
Apr. 15	48	100	12. 9±0. 26	12. 1±0. 21
May 15	28	200	9. 5± . 34	9. 2± . 31

It will be noted that in both years the yields were slightly higher under the two-plant-per-hill system of spacing than under the one-plant system, but the differences were in neither case significant. It is indicated that there is no sacrifice of yield in leaving two plants to the hill and that it is unnecessary to practice exact or painstaking methods in the effort to leave only one plant to the hill.

Comparison of spacing in 1923.—In 1923 the Pima, Acala, and Hartsville varieties were planted alternately on six plats. One plat of each variety was planted in rows spaced 2½ feet apart, and in another plat of each variety the rows were 3½ feet apart. In one-half of the rows in each plat the plants were thinned to 6 inches apart and in the remaining rows to 12 inches apart. The yields obtained are shown in Table 11.

TABLE 11.—*Yields of seed cotton produced by Pima, Acala, and Hartsville varieties in spacing experiments at the United States Field Station, Sacaton, Ariz., in 1923*

Spacing distance		Pima	Acala	Harts-ville
Between rows	Between plants			
		Pounds	*Pounds*	*Pounds*
30 inches	6 inches	1, 149	2, 203	1, 697
	12 inches	912	2, 070	1, 542
42 inches	6 inches	1, 313	1, 910	1, 428
	12 inches	1, 164	1, 458	1, 362

Table 11 shows that the yields from plantings with the 6-inch spacing were uniformly and materially higher than those from the 12-inch spacing. The 30-inch rows also produced greater yields than the 42-inch rows with the upland varieties. The notably low yield in the Pima plat with the 30-inch row spacing can be attributed to the fact that this plat contained alkali spots of considerable area, which reduced the size of the plants and the yields. The other plats were not seriously affected.

Comparison of spacings in 1924.—In 1924 a comparison was made between alternate three and four row plantings of Pima cotton spaced 12 inches apart in the row and unthinned plantings, and a similar comparison between plants unthinned and others spaced 6 inches apart. The mean yield per row of the three spacings is given in Table 12.

TABLE 12.—*Yields of Pima seed cotton in unthinned plantings compared with spacings of 12 and 6 inches between plants at the United States Field Station, Sacaton, Ariz., in 1924*

Spacing distance	Number of rows 75 feet in length	Yield per row (pounds)
12 inches	11	6.6±0.37
6 inches	9	5.0± .19
Unthinned	20	5.8± .24

In this experiment the differences in yield are not sufficiently large to indicate any particular advantage of one system of spacing over another. It suggests that yields from unthinned plantings may compare favorably with yields from thinned plantings of the same area.

TIME-OF-PLANTING EXPERIMENTS

Experiments conducted since 1917 for the purpose of determining the optimum date of planting for Egyptian cotton have shown that plantings made at Sacaton during the month of March have given consistently higher yields than later plantings. This investigation was continued in 1922; but the yields were somewhat affected by an attack of the root-rot disease, which was more severe on some plats than on others.

In 1923 an experiment was begun in an effort to determine whether late planting would have a less depressing effect upon the yield of upland than of Pima cotton. Pima and Acala varieties were planted in alternate borders, one border of each at intervals of 20 days, from March 20 to May 20. On April 10 two plats of each variety were planted alternately for the purpose of water-requirement studies. The yields per acre from the different plantings are given in Table 13 and indicate that Upland varieties may be planted much later than Pima without impairing the yield.

TABLE 13.—*Comparative yields of seed cotton of the Pima and Acala varieties on alternate plats in date-of-planting experiments at the United States Field Station, Sacaton, Ariz., in 1923*

Variety	Dates of planting and acre yields (pounds)			
	March 20	April 10 [1]	April 30	May 20
Pima	1,528	1,391	1,420	1,033	743
Acala	1,938	2,270	2,739	2,174	1,895

[1] Two plats of each variety were planted on April 10.

In the valleys of southern Arizona, where the winters are sufficiently mild to permit the production of many winter crops, the

farmers are often confronted with the problem of what is the most profitable crop to plant in the summer following the harvesting of the winter crops. Many farmers in the Salt River Valley have adopted the practice of planting upland cotton following the harvesting of grain and truck crops, which is usually completed in June. Some of these farmers have failed to recognize that there are differences in the early-maturing qualities of the upland varieties and that such qualities are important even in areas where there is no boll-weevil problem.

In order to obtain data that would show whether or not summer plantings of cotton are advisable and which varieties are best adapted for such practice, a comparison was made in 1922 between a plat of Hartsville cotton planted on June 5 and adjacent plats of Pima and Acala varieties planted on June 22. In 1923, plantings of one plat each were made of Acala and Hartsville varieties on alternate plats on April 30, May 20, and June 20. The results of the comparisons made in both 1922 and 1923 are recorded in Table 14.

TABLE 14.—*Comparative yields of seed cotton produced by Pima, Acala, and Hartsville varieties from late plantings made at the United States Field Station, Sacaton, Ariz., in 1922 and 1923*

Variety	Date planted	Acre yields (pounds)	Variety	Date planted	Acre yields (pounds)
Pima	June 22, 1922	(1)	Acala	May 20, 1923	1,577
Acala	do	858	Hartsville	do	1,066
Hartsville	June 5, 1922	798	Acala	June 20, 1923	133
Acala	Apr. 30, 1923	1,615	Hartsville	do	121
Hartsville	do	1,488			

[1] Did not mature.

ROTATION EXPERIMENTS

The two-year rotation experiments begun in 1917 and combined with continuous-cropping experiments conducted since 1911 were continued in 1922 and 1923.

TABLE 15.—*Yields of crops in rotation experiments at the United States Field Station, Sacaton, Ariz., in stated years*

Crops grown	Plat No.	Acre yields of seed cotton (pounds)							Acre yields of other crops				
		1918	1919	1921	1922	1923	1924	Average	Unit of yield	1921	1922	1923	1924
Cotton continuously	D2-10	1,652	885	990	1,304	1,024	993	1,141					
Cotton continuously, manured in alternate years	D2-11	1,760	1,391	1,454	1,558	1,852	1,097	1,519					
Cotton-alfalfa rotation	D2-12		1,389		1,415		1,430	1,411	Ton	3.8		3.2	
Do	D2-13	1,516		1,676		1,912		1,701	do		3.6		3.4
Cotton-corn rotation, not manured	D2-14		1,203		1,626		917	1,249	Bushel	39.7		12.3	
Cotton-corn rotation manured	D2-15	1,970		842		1,863		1,558	do		23.7		25.8
Cotton-corn rotation	D2-16		1,076		941		765	927	Bushel	56.2		10.3	
Do	D2-17	1,658		965		1,878		1,500	do		24.3		25.3
Cotton and corn intercropped with soy beans[1]	D2-18		804		1,061		858	908	do			20.0	
Cotton-corn rotation	D2-19	1,332				1,772		1,552	do		23.0		16.5
Cotton-milo rotation	D2-20		1,084		895		1,205	1,061	do	34.0		41.2	
Do	D2-21	2,312		1,103		2,148		1,854	do		27.4		36.3
Cotton-Sudan-grass rotation	D2-22		1,336		1,394		1,160	1,297	Ton	4.2		4.8	
Do	D2-23	2,396		1,427		2,020		1,948	do		5.5		3.7

[1] Soy beans failed to grow on account of alkali; guar and cowpeas substituted.

It is hoped that information may be obtained from these experiments which will indicate the most profitable Arizona crop to grow in alternation with cotton and bear upon the problem as to how quickly successive crops of cotton will lower the productivity of Arizona soils. The cotton yields for six years and the yields of the other crops for four years are given in Table 15.

The accumulation of alkali salts in the soil of the series of plats on which the experiment is conducted tended to complicate the results, the least affected being D2 plats 21, 22, and 23. The efficacy of manure treatments and alfalfa rotation in increasing yields, however, is indicated and suggests methods of improvement of soils rendered unproductive by alkali salts.

COTTON PRODUCTION AT THE SEED FARM

In continuance of the purpose of supplying pure strains of seed for use by the Indians on the reservation it has been the policy at the seed farm to confine each field crop to one variety. There has been no conclusive evidence that Pima Egyptian cotton, Sacaton June corn, and Hairy Peruvian alfalfa are not the best varieties of these three crops for growing under local conditions, and their production has been continued. Part of the farm has been planted to alfalfa to restore the fertility of the soil reduced by other crops and to provide productive land for future use.

In 1922 the per acre production of cotton was slightly less than in the previous year, when the highest yields were recorded since the seed farm was established. The same land was planted, this being its second year in cotton. Prior to 1921 it had been planted for periods of two to three years to Hairy Peruvian alfalfa. The growing conditions during 1922, which are referred to under "Climatic conditions," were hardly as favorable as during 1921 and were a contributing factor to the somewhat reduced yields. The average yield per acre for 1922 was 1,213 pounds of seed cotton, or about two-thirds of a bale of lint, a reduction of about 100 pounds of seed cotton per acre from the previous year. There was an increased production over the previous year on the land which had been planted two and one-half years to alfalfa, but the soil in this tract is naturally more fertile than the remainder of the area.

A half acre of raw desert land adjoining the main cultivated field was graded and planted in 1923. This plat yielded at the rate of 626 pounds of seed cotton, or about one-third of a bale per acre. A similar half acre of land which had been planted the year before was again planted and produced at the rate of 1,127 pounds of seed cotton per acre, or an increase of 461 pounds over the previous year. This increased production was obtained without special treatment or the addition of fertilizers and would indicate that new land is much benefited by cropping and systematic cultivation for even a single year.

In 1923 part of the land which had been in cotton in 1922 was again planted, this being its third successive year in that crop. The remaining acreage of cotton in 1923 was on land which had been cropped for three years to alfalfa and one year to corn. The yields from both these areas were nearly the same, being approximately two-thirds of a bale per acre, or about the same as the previous year.

In 1924 the cotton acreage was shifted to a section of the farm on which alfalfa had been growing for periods of two to five years. An

improved strain of smooth-seeded Pima, mentioned elsewhere in this circular, was planted in order that the supply of seed might be increased. Considerable difficulty was encountered during the summer in maintaining sufficient water in the soil for all the requirements of the plants. This lack of water was due in part to the continuous hot dry weather and in part to the fact that in portions of this farm the land has more slope than in other parts, making it difficult to hold irrigation water long enough for a thorough penetration of the soil to be effected. As a consequence, in portions of the field the plants were considerably reduced in size and productiveness. The average acre yield was 749 pounds of seed cotton.

AN IMPROVED STRAIN OF PIMA COTTON [6]

The outstanding recent development in the Egyptian cotton-breeding work has been the origination of a uniformly smooth-seeded strain of the Pima variety.[7] It has been found that with seed of this character the capacity of the roller gins is practically doubled. In other words, a given weight of seed cotton of the new strain can be ginned in about half the time required to gin an equal quantity of ordinary Pima. Furthermore, the gins work better, as less of the fiber goes through with the seed, and there seems to be less tendency for the lint to become curled or ropy. The almost complete absence of fuzz on the seeds makes it unnecessary to delint the planting seed.

The new strain appears to be satisfactory in the strength and quality of the fiber. Such data as are available indicate that it equals ordinary Pima in productiveness. A spinning test of the fiber, in comparison with ordinary Pima, is being conducted by the Bureau of Agricultural Economics. During the coming season further comparative yield tests will be made and seed will be increased at the seed farm and in the Salt River Valley. The results of these tests must be awaited before a decision can be reached as to whether the smooth-seeded strain should be substituted for the present commercial stock of Pima cotton.

STUDIES OF COTTON HYBRIDS, POLLINATION, AND CELL-SAP PROPERTIES

A promising cross between Pima and Sakellaridis, the best variety grown in Egypt, which seems to combine the desirable plant characters of the former with the fiber properties of the latter, is being tested as to its agricultural and commercial possibilities. Crosses between Pima and sea-island cotton also are being tested, but so far they seem less promising than the Pima-Sakellaridis combination.

The results of investigations in the pollination of cotton and of the inheritance of characters in a hybrid between upland and Pima cottons, long continued at Sacaton, have been published recently.[8] The pollination studies have been continued, and it has been demonstrated that selective fertilization occurs in both upland and Egyptian cotton; that is, when flowers of either type are pollinated with a

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[6] This section and the one following, relating to the work conducted at Sacaton by the Office of Alkali and Drought Resistant Crops, were prepared by T. H. Kearney.

[7] This strain is derived from a smooth-seeded plant selected by W. F. Gilpin in a field of Pima cotton at Sacaton in 1920.

[8] Kearney, T. H. Self-fertilization and cross-fertilization in Pima cotton. U. S. Dept. Agr. Bul. 1134, 68 pp., illus. 1923.

——— Segregation and correlation of characters in an upland-Egyptian cotton hybrid. U. S. Dept. Agr. Bul. 1164, 58 pp., illus. 1923.

mixture of pollen of both types, approximately 75 per cent of the ovules are fertilized by the like pollen.[9] Investigations are under way with the object of ascertaining at what distance, under Salt River Valley conditions, seed-increase fields should be isolated from other cotton in order to eliminate accidental cross-pollination as a factor affecting the purity of the seed.

A strain of Pima cotton in which the red spot near the base of the petal is absent or nearly so has been crossed with a normal or full-spotted strain of the same variety, and study of the progeny in three generations has shown the spotless character to be a simple Mendelian recessive, one-fourth of the second-generation hybrid plants being spotless.[10] This character is of no direct practical importance, but it should be useful as the hall mark of an agriculturally valuable strain, since, the spot being almost completely dominant, a first-generation hybrid with a normally spotted strain invariably has a well-developed petal spot. Accidental hybrids with ordinary Pima could therefore be recognized and removed from seed-increase fields of a strain having spotless petals as soon as the plants begin to blossom. The simple inheritance of the spotless character should make it readily transferable to any desirable strain of this variety.[11] In order to ascertain whether this is the case, spotless Pima has been crossed with the smooth-seeded strain of this variety, smooth seededness also appearing to be a simple Mendelian character.

Investigation of the cell-sap properties of various types of cotton are being continued at Sacaton by J. Arthur Harris and his associates, and the earlier results have been published.[11] It has been found that Pima, as compared with upland cotton grown under identical conditions, has a consistently higher osmotic pressure and salt content of the leaf sap, a difference which points to the conclusion that the Pima variety is somewhat better adapted than upland to land containing alkali. An interesting point brought out by the investigation is that when the two types are growing side by side, hence under identical soil conditions, the leaves of Pima contain more chlorides while those of upland cotton contain more sulphates. This difference in selective absorption of salts from the soil solution indicates a rather profound physiological difference between the two types of cotton and may eventually help to explain certain other differences in their behavior. Some of the results of this investigation have been published recently.[11]

Investigation of the salt content of the fiber of Pima cotton in comparison with that of upland and of sea-island cotton grown under similar soil conditions at Sacaton has shown practically no difference among the three types, and fiber of Meade upland and sea-island cottons grown at Sacaton did not show a materially higher salt content than fiber of the same types grown in South Carolina.[12] At

[9] Kearney, T. H., and G. J. Harrison. Selective fertilization in cotton. *In* Jour. Agr. Research, vol. 27, pp. 329–340. 1924.

[10] Kearney, T. H. Inheritance of petal spot in Pima cotton. *In* Jour. Agr. Research, vol. 27, pp. 491–512, illus. 1924.

[11] Harris, J. A., Z. W. Lawrence, W. F. Hoffman, J. V. Lawrence, and A. T. Valentine. The tissue fluids of Egyptian and upland cottons and their F₁ hybrid. *In* Jour. Agr. Research, vol. 27, pp. 267–327, illus. 1924.

——— J. V. Lawrence, and Z. W. Lawrence. The chlorid content of the leaf-tissue fluids of Egyptian and upland cotton. *In* Jour. Agr. Research, vol. 28, pp. 695–704. 1924.

——— C. T. Hoffman, and W. F. Hoffman. Sulphate content of the leaf-tissue fluids of Egyptian and upland cotton. *In* Jour. Agr. Research, vol. 31, pp. 653–661. 1925.

[12] Kearney, T. H., and C. S. Scofield. The salt content of cotton fiber. *In* Jour. Agr. Research, vol. 28, pp. 293–295. 1924.

Sacaton the Pima fiber from plants growing in strongly saline soil had a slightly higher salt content than fiber from plants growing in good soil, but there was no corresponding difference in the hygroscopic moisture capacity of the fiber. There is no evidence, therefore, that the salt content of Pima fiber is a factor in its spinning properties.

Another recent discovery is that the length of the fiber on the same individual plant of Pima cotton varies according to the position on the plant of the boll containing it, increasing steadily from the lowest to nearly the highest bolls.[13] It has also been ascertained that abortion of the terminal bud of the main stalk in Pima cotton, a rather frequent deformity, is not hereditary.[14]

OTHER FIELD CROPS

During the years 1922, 1923, and 1924, breeding material and new introductions of small grains have been grown at the field station.

The Chief of the Bureau of Plant Industry, conforming to the regulations of the Federal Horticultural Board, has designated Sacaton as a quarantine point where new introductions can be grown. There are several advantages in making the first planting of foreign varieties at Sacaton. Often it is not known whether these importations are spring or winter sorts, and seed of either is produced here readily so that an ample quantity becomes available for distribution to experiment stations the second year. Apparently leaf diseases do not survive through Sacaton conditions. Spikes of barley infected with Helminthosporium leaf-blotch have been found to be sterilized by the sun and to produce clean plants the second year.

BARLEY [15]

At first the small-grain work, conducted at Sacaton, was largely with barley. In 1922 second generations of 33 crosses were grown and notes taken in a study of genetic characters in barley. Several cases of linkage were observed, notably one of density with height and other plant characters.

During the crop year 1923 a nursery consisting of pure lines of about 700 varieties of barley in competition with each other was grown at Sacaton. Of these varieties 113 had been selected for growing under both irrigated and dry-land conditions in 1924. From this nursery it is hoped that forms suitable for Arizona conditions may be obtained. In addition, 850 rows of inheritance material in barley were grown. In 1924 the genetic studies were continued in the third generation. At the same time more than 700 varieties and selections made by H. V. Harlan in North Africa and Kashmir were grown for the first time in America. Many of those from Egypt were particularly promising. A large number of these Egyptian selections were of the Club Mariout type, which has been so successful and popular in California recently.

Most varieties of barley produce good yields when grown at Sacaton.

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[13] Kearney, T. H., and G. J. Harrison. Length of cotton fiber from bolls at different heights on the plant. *In* Jour. Agr. Research, vol. 28, pp. 563–565, illus. 1924.

[14] Kearney, T. H. Non-inheritance of terminal bud abortion in Pima cotton. *In* Jour. Agr. Research, vol. 28, pp. 1041–1042, illus. 1924.

[15] Prepared by H. V. Harlan, of the Office of Cereal Crops and Diseases, under whose direction the work on barley was conducted.

WHEAT [16]

Wheat continued to hold first place in the area planted to crops by the Pima Indians during 1922, 1923, and 1924. The principal varieties grown on the reservation are Baart (*Early Baart*), Sonora, and Little Club. The variety test conducted since 1918 in cooperation with the Office of Cereal Investigations of the Bureau of Plant Industry was continued during 1922, 1923, and 1924. The yields per acre of the different varieties for six years are given in Table 16.

TABLE 16.—*Yields of wheat varieties grown at the United States Field Station, Sacaton, Ariz., from 1919 to 1924, inclusive*

Class and variety	Acre yields (bushels)							
	1919	1920	1921	1922	1923	1924	Average	3-year average for 3 leading varieties during comparable years
Common white:								
Baart (*Early Baart*)	45.3	----	53.5	38.2	42.5	54.7	[1] 46.8	45.7
Sonora	59.0	43.6	31.5	30.3	32.6	61.7	43.1	----
Pacific Bluestem	46.0	53.0	27.5	43.7	43.6	42.7	42.7	----
Hard Federation	----	53.3	31.0	28.0	30.8	34.5	[1] 35.5	----
White Federation	----	42.8	25.8	30.1	39.2	41.1	[1] 35.8	----
Federation	----	----	----	----	22.4	39.2	----	---- --
Hard red winter:								
Kharkof	47.5	61.9	44.0	41.5	----	----	[2] 48.7	44.3
Soft red winter:								
Triplet	44.8	56.7	43.0	33.9	27.8	----	[1] 41.2	----
Hard red spring:								
Marquis	46.8	33.8	36.6	36.1	41.2	36.8	38.6	----
Club:								
Little Club	55.9	52.0	46.2	26.2	52.2	56.5	48.2	42.8

[1] Average for five years. [2] Average for four years.

It is unfortunate that the data on the highest yielding varieties are incomplete. By accident the yield of Baart in 1920 was combined with that of a bulk planting and is not comparable. In 1923 a poor stand resulted from the Kharkof planting, and the yield was not recorded. The data are sufficient, however, to indicate that the Baart variety is superior in producing qualities over the other varieties in the same class, and this superiority and its high qualities for bread making seem to justify it as the leading variety grown in the wheat-producing area in Arizona. The low-growing stems and awnless spikes of the Federation present a disadvantage for growing these varieties on the Gila Reservation, where bird damage is an important factor to be considered.

Comparative tests of Baart and Hard Federation were conducted in 1924 in order to ascertain whether there was a difference in the yielding qualities. The two varieties were planted alternately on one-fifth acre plats which were sandy and not highly productive. The yields computed on an acre basis are given in Table 17.

[16] Prepared by C. E. Leighty, of the Office of Cereal Crops and Diseases, who conducted the work on wheat breeding.

TABLE 17.—*Yields of Baart and Hard Federation wheat varieties on alternate plats at the United States Field Station, Sacaton, Ariz., in 1924*

Plat	Acre yields (bushels)		Plat	Acre yields (bushels)	
	Baart	Hard Federation		Baart	Hard Federation
No. 1	30.6		No. 6		34.7
No. 2		28.3	No. 7	34.7	
No. 3	28.9				
No. 4		31.6	Average	32.0	31.6
No. 5	33.7				

An irrigation experiment with Baart wheat was conducted in 1924 in the effort to determine the practicability of storing large quantities of water in the soil before planting, for supplying the crop during periods of water shortage in the early spring. The Indians and the white farmers in the middle Gila Valley, many of whom depend largely on the periodic flow of the Gila River for producing a wheat crop, frequently have abundant river water in the early winter months, but very little in March, April, and May, when the spikes are developing.

The irrigation experiment, which also included a test of light and heavy seeding and one planting made on the moisture supplied entirely by rainfall, attracted considerable attention among the local farmers. The results of the test are given in Table 18.

TABLE 18.—*Yield of Baart wheat produced under varied irrigation treatments and with different rates of seeding at the United States Field Station, Sacaton, Ariz., in 1924*

[There were 2.36 inches of precipitation in November and 3.25 inches in December, 1923]

Plat	Treatment	Rate of seeding per acre (pounds)	Acre yields (bushels)
No. 1	5 acre-inches of water applied before planting; later irrigations were given Jan. 22, Feb. 5, Mar. 25, and Apr. 29.	70	33.7
Nos. 2 and 3	7 acre-inches of water applied before planting; a later irrigation was given Mar. 25.	70	36.8
		35	43.2
Nos. 4 and 5	7 acre-inches of water applied before planting; later irrigations were given Feb. 5 and Mar. 25.	70	45.5
		35	41.0
Nos. 6 and 7	Planted after a rain; irrigations were given on Feb. 5 and Mar. 25.	70	29.6
		35	25.8

An unusually heavy precipitation occurred in December, 1923, following the planting of wheat on November 27, and it undoubtedly had an important influence on the results of the experiment. The data suggest, however, that frequent applications of water to the wheat crop on the alluvial soils along the Gila River are not always advantageous and can be avoided if heavy irrigations are applied before planting. It is indicated that large crops of wheat can be produced on much of the Indian land with only one irrigation after planting if previous storage of water in the soil is practiced. (Fig. 6.)

In addition to the plat tests conducted with several varieties of wheat already mentioned, about 450 introductions from foreign countries in all parts of the world were grown in 1924.

From the seed thus produced, nurseries were sown in several parts of the country for further tests the following year, and several of the strains which seemed best adapted to local conditions were seeded in comparative tests with the best wheats now being grown in this locality. In addition to these introductions, the progenies of several crosses were grown for genetic studies. These included crosses between winter and spring types, which at Sacaton can be grown in the open from fall seeding. Conditions at the field station are very favorable for the production of material for such studies, as injury by disease is rare and the proper characters of the plants are not obscured by unfavorable climatic conditions or fungous growths.

FIG. 6.—Field of Baart wheat produced with only one irrigation after sowing in 1924 at the United States Field Station, Sacaton, Ariz

GRAIN SORGHUMS

Tests were made in 1922 and 1923 for the purpose of comparing several varieties of grain sorghum. The yields per acre are given in Table 19.

TABLE 19.—*Comparative yields of grain-sorghum varieties grown at the United States Field Station, Sacaton, Ariz., in 1921, 1922, and 1923*

Variety	Acre yields (bushels)			Variety	Acre yields (bushels)		
	1921	1922	1923		1921	1922	1923
Standard Yellow milo	59.7	68.3	46.1	Dwarf hegari	16.6	32.6	
Dwarf Yellow milo	49.3	64.9	40.3	Feterita	36.1	22.5	
Early White milo	32.8	26.9		Blackhull kaoliang	25.4	31.4	
Red kafir	17.7	40.0		Manchu kaoliang	12.3	18.8	
Blackhull kafir	29.5	25.6		Shantung kaoliang	7.5		
Sunrise kafir	16.4	16.1		White durra	24.8	6.6	
Standard hegari	47.0	42.8	36.5	Shallu	48.5	26.0	

It would appear from the yields shown in Table 19 that Standard Yellow milo is the best adapted of all the grain sorghums under the conditions which obtain at Sacaton. Although the yields are not materially higher than those of the dwarf variety, the advantage

which the latter possesses in having a lower water requirement is overbalanced by a distinct disadvantage as an Indian crop in being more susceptible to damage from birds, a factor which is of no little importance with the grain crops grown on the scattered Indian farms of the reservation.

CORN

The experiments with corn were conducted in much the same manner as in former years. (Fig. 7.) The testing of native Indian

FIG. 7.—Field of Mexican June corn at the United States Field Station, Sacaton, Ariz. (in the background). The tepary beans in the foreground were grown for soil improvement

varieties was continued in 1922 and 1923, the Apache and Papago varieties being added in 1923. The yields for three years are given in Table 20.

TABLE 20.—*Comparative yields of varieties of corn at the United States Field Station, Sacaton, Ariz., in 1921, 1922, and 1923*

Variety	Source	Acre yields (bushels)			
		1921	1922	1923	Average
Pima	Gila River Reservation, Ariz	16.4	27.4	28.1	24.0
White soft	Colorado River Reservation, Ariz	19.8	23.7	15.3	19.6
San Tan Yellow (flint)	Gila River Reservation, Ariz	30.0	36.6	54.1	40.1
Squaw	Rosebud Reservation, S. Dak	3.0	13.7	14.8	10.5
Hopi	Hopi Reservation, northern Arizona	6.6	30.4	27.6	21.5
Hedog	Rosebud Reservation, S. Dak	4.1	16.4	12.2	10.9
Apache	White River Reservation, Ariz	------	------	29.7	------
Papago sweet	Papago Reservation, Ariz	------	------	35.7	------
Sacaton June	Gila River Reservation, Ariz	52.0	41.2	77.1	56.8

Table 20 shows that the best results were obtained with the local varieties. The superiority of the Sacaton June variety can hardly be questioned in the light of these results, but for the Indians who are dependent on the irregular flow of the Gila River some of the quicker maturing varieties fill an important need. Many of the Indians are able to produce substantial yields on the Pima soft and the San Tan Yellow flint varieties with only one irrigation, because of the short period required for development and their low water requirements.

Corn following other crops.—In 1922 Sacaton June corn was grown on 2½ acres of land at the seed farm, which had for three years previous been in alfalfa. A strain selected for resistance to alkaline soil conditions was grown in comparison with the regular stock, but no differences of growth or yield were noted. The yield per acre for this year was 46.6 bushels.

In 1923, 2¾ acres previously in cotton for two years and before that planted to alfalfa were planted to corn, and in spite of the cropping to cotton they gave better yields than the land used for this crop the year before, averaging 57.1 bushels per acre.

Corn-breeding experiments.[17]—Since 1918 the station has cooperated with the Office of Biophysical Investigations, Bureau of Plant Industry, in conducting a comparison of breeding methods for corn.

The two methods compared in this experiment were:

(1) An ear-to-row method in which the selections were from hand-pollinated seed, the average yield of the parents being the criterion of selection.

(2) A method of inbreeding in which the foundation stock was analyzed into self-pollinated lines, those showing deleterious characters or low yields being eliminated, the remaining ones being recombined to restore vigor.

The general idea of this second method is to free the variety from deleterious variations that would persist in crossbred stocks by virtue of their recessive nature.

The variety chosen was Sacaton Laguna, a variety of Mexican June corn developed at the station through ear selection. Twenty ears were chosen as a foundation stock. The seed from each of these ears was divided, one half forming the foundation stock of the crossbred method, the other half forming the foundation of the selfing method.

In the seasons of 1923 and 1924 field tests were made of the results of the two methods of breeding and the original Sacaton June.

The comparison of the two methods of breeding has given somewhat contradictory results. In 1923 the crossbred seed outyielded the selfed, but in 1924 the position was reversed. In both seasons, however, the seed from both of the breeding-method experiments showed substantial increases over the regular station stock.

The improved seed is now available for general planting.

ALFALFA

Alfalfa occupied third place in value of farm products grown by the Indians on the Gila River Reservation in 1923. About 1,000 acres are usually devoted to this crop by the Indians for hay production, practically all of which is the Hairy Peruvian variety. For increasing the productivity of soils that indicate a worn-out condition and for the improvement of virgin soils in preparation for general cultivation, no better method has been demonstrated in this region than cropping to alfalfa for several years. That Arizona ranked second among all of the cotton-growing States in 1923 in quantity of lint produced per acre is attributed by many to the fact that much of the land devoted to cotton in the State had been put in proper condition in previous years by crops of alfalfa.

Extensive tests have been made for comparing alfalfa varieties at the field station since 1907, and the superiority of the Hairy Peruvian variety for local conditions has been repeatedly demon-

[17] Prepared by G. N. Collins, senior botanist in charge of the biophysical laboratory, under whose direction the experiments were conducted.

strated. A test planting was made in the spring of 1923, comprising the Hairy Peruvian, Smooth Peruvian, Indian, Chilean (Arizona common), Turkestan, and Kansas varieties. The last two varieties named produced poor stands and soon became almost exterminated by Bermuda grass, which is a serious competitor of young alfalfa on some of the older cultivated lands of this region. The other varieties made a good start and although the yields so far have been too light to be of significance it is believed that the results for another season will be of value.

The Hairy Peruvian alfalfa is grown on most of the land under cultivation at the seed farm, principally for soil improvement, but also for the production of seed for distribution to the Indians on the reservation. Some difficulty has been encountered in making good yields of seed, due in a large degree to the low water-holding

FIG. 8.—Field of Bermuda onion seed grown at the United States Field Station, Sacaton, Ariz.

capacity of the soil. This necessitates frequent irrigations. These are undesirable in growing alfalfa for seed, since they keep the plants in a continuous state of growth, which does not favor the setting and maturing of seed. The best yield produced was in 1922, when 1,022 pounds of seed of very good quality was produced on 3.1 acres of land, being at the rate of 329 pounds per acre. The fields not used in seed production have been cut for hay, averaging five to six cuttings a year.

SORGOS

The interest which was created among the Pima Indians by the field station in the early years of its existence for producing sirup from sorgos (saccharine sorghums) has been maintained. Many of the Indians near Sacaton devote a small portion of their cultivated lands to sorgos for sirup making and for forage.

A test planting was made in 1923 with the best-known sirup-producing varieties. The gross yields (in tons) of the different varieties were as follows: Texas Ribbon, 19.5; Black Amber, 5.8; Red Amber, 9.6; Honey, 11.3; Sumac, 10.3; White African, 13.9; Orange, 8.1.

SWEET POTATOES

Special effort is being made at the field station to increase the interest of the Indians in the production of sweet potatoes, especially for home consumption. Experiments have demonstrated conclusively that the soil along the Gila River is capable of producing large yields of sweet potatoes, and there is apparently no reason why this crop should not occupy an important place in the agriculture of the Indians.

No extensive variety tests have been conducted in recent years at the field station, but plantings of the Georgia "yam" variety produced at the rate of 4.2 tons per acre in 1922 and 4 tons in 1923. A yield at the rate of 7.6 tons per acre was obtained from a planting of the Porto Rico variety in 1923.

FIG. 9.—Field of yellow Bermuda onions grown at the United States Field Station, Sacaton, Ariz.

ONIONS

The development of improved strains of onions has been carried on at the field station for many years. Special attention has been given to a strain of yellow Bermuda (often called white Bermuda) onion which has acquired the name of Sacaton Bermuda in the local community. This strain was developed by careful selection of a type of bulb desirable to plant for seed production. Care was taken to select only those bulbs which were symmetrical and free from cupped or concave surfaces, thin centers, or lobed sides. Pure seed stocks of this strain have been maintained at Sacaton for several years, and the home-grown seed appears to be superior to the imported Teneriffe seed. (Fig. 8.)

The average yield of four plats of yellow Bermuda onions at the station in 1924 was at the rate of 5.3 tons per acre. Under the most favorable conditions and with closer spacing of rows than was practiced in 1924 this variety has yielded at the rate of 27½ tons per acre. (Fig. 9.) Much of the Indian land along the Gila River is well

suited for onions, and should marketing conditions become more favorable for the Arizona crop, on account of the newly developed onion industry in the southern counties, the Indians would have several advantages in engaging in the commercial production of onions. Many of them already grow small patches of Bermuda onions for home use, and the station distributes large quantities of seed and seedling plants to them every year.

For producing onions successfully it is necessary to observe certain precautions in land selection and cultural practice. The soil should be of a type that does not crack severely after wetting and should be fairly free from saline materials. Heavy applications of organic manures should be made before preparing the land, and after the plants are set out the cultivations should be frequent enough to prevent any baking of the soil surface.

FIG. 10.—Row of 4-year-old apricot and peach trees at the seed farm, Sacaton, Ariz.

FRUIT CROPS

DECIDUOUS FRUITS

At the time the seed farm was established, a tract of land was set aside for the testing of fruit crops upon the sandy soil, which is typical of large areas in this part of Arizona. The first trees, 80 in number, were planted in the spring of 1917, and each year since then additions have been made to the orchard until at present there are 270 trees. The fruits now being tested comprise the following varieties: Peaches, 24, apricots 5, nectarines 6, plums 7, prunes 5, quinces 3, pears 7, figs 15, Japanese persimmons 4, olives 3, almonds 8.

The standard varieties of peaches, such as Crawford, Elberta, and Phillips Cling, are growing very satisfactorily (fig. 10), but have not been tested for a period sufficiently long to indicate how they will fruit under local conditions. Among the trees which have been longest under test, a freestone variety known as Pallas has produced abundantly for the past three seasons. This is an early-ripening peach (June and July) of the Honey type, of South Chinese origin,

with greenish-white skin and flesh. It is a very delicious peach for use in the fresh state, but has little value for canning or preserving and probably would not ship to good advantage. Another peach of similar character, fruiting for the first time in 1923, is the Lukens Honey, which ripens about the middle of August.

The varieties of apricots which have fruited are the Newcastle, Blenheim, Tilton, Moorpark, and Royal. (Fig. 10.) The Newcastle is the earliest to ripen, followed by Blenheim and others from two to three weeks later. All bore light crops in 1922 and 1923. In 1924 the Newcastle variety produced an average of 80 pounds per tree and the Blenheim and Royal trees about 50 pounds each. The other two varieties yielded somewhat less.

Up to the present time the prune and nectarine trees have failed to fruit, although they are several years old.

Of the plum varieties represented, the Santa Rosa has thus far proved to be much the best. Two of the older trees of this variety, which were planted in 1917, have borne fruit for the past four years and in 1924 had particularly good crops, one of them bearing 130 pounds of fruit. The Wickson, Beauty, and Satsuma varieties have produced light crops for the past three years but do not show promise of being very productive.

Quinces of the Weeks Prolific and Smyrna varieties have borne only very small crops of fruit.

Pears give indications of being poorly suited to the soil at the seed farm. However, the Bartlett and Winter Nelis varieties have produced heavily in some years at the field station.

Among the figs which are in bearing, the Brown Turkey and Mission varieties have outyielded the rest. The former seems especially well adapted to its environment and produces heavy crops of fruit through most of the summer and well into the fall. The white varieties represented by Pacific, Adriatic, and San Pedro usually bear good crops both at the seed farm and the field station, but most of the fruit sours before ripening.

The four varieties of Japanese persimmons under test have not appeared to be well adapted to conditions at the seed farm. The trees have made little growth, and the intense heat and atmospheric aridity of summer have apparently caused the fruit to blast. It is known, however, that this fruit can be successfully grown in parts of this region.

The standard almonds, such as I. X. L. and the papershelled varieties, have failed to set crops, although they have blossomed heavily in the spring. These trees are in somewhat isolated positions and probably their flowers do not become properly cross-fertilized, which would account for their failure to bear. Younger trees of Spanish and Asiatic varieties imported by the United States Department of Agriculture usually set and mature fair crops.

Pomegranates have been slow to obtain a place as a market product in Arizona. In recent years, however, they have received some attention from the trade in the markets of the Salt River Valley, where they are in considerable demand by the Mexican and Indian populations. Even at $40 or $50 a ton, which is the wholesale price sometimes offered for the redskin varieties, a considerable profit might often be realized from a crop which bears so profusely and requires so little attention.

At the field station, the Wonderful is the most popular variety with the Indians, with the Greenrind, Sweet (*Sweet Fruited*), and Hermosillo also in great demand. Many cuttings and rooted plants of these varieties are distributed among the Indians each year by the field station.

OLIVES

A planting of 72 trees of the Chemlali olive [18] (fig. 11), an African variety of particular value for oil production, was made in 1920, and the trees have made a very satisfactory growth on virgin desert soil without fertilizers and with little irrigation. In 1924 most of these trees bore light crops. The Mission and Grosse Aberkan, the latter another African variety, are also being grown but have not fruited.

FIG. 11.—Row of 5-year-old Chemlali olive trees at the seed farm, Sacaton, Ariz., in 1924

CITRUS FRUITS

In addition to the deciduous fruits and olives at the seed farm, there is a planting of citrus consisting of oranges, grapefruit, citrangequats, limequats, and numerous other hybrids and stocks. The planting was started in the spring of 1919 and at the present time consists of 102 trees. The original planting as received from the greenhouses of the Office of Crop Physiology and Breeding at Washington, D. C., comprised 155 plants of 43 different sorts, largely hybrids. These were all small plants, originally grown in pots. During the first summer they were set out, 42 of the plants succumbed, and the following winter a number of others were killed by unusually cold weather. Subsequent shipments from Washington of plants judged to be more likely to succeed under desert conditions have been made, until most of those now growing give promise of being suitable for propagation. Those that have made the best growth have been of trifoliate-orange blood, such as the Rusk, Colman, and Cunningham citrange seedlings; the citrangequat, a

[18] Kearney, T. H. Dry-land olive culture in northern Africa. *In* U. S. Dept. Agr., Bur. Plant Indus. Bul. 125, pp. 19–20. 1908.

cross between the citrange and kumquat (fig. 12);[19] the citrandarin, a trifoliata-mandarin orange cross; and the citrumelo, a trifoliata-grapefruit cross. The first three of these are valuable principally as stocks for grafting or budding to other varieties. Some of these trees bore fruit during the seasons of 1923 and 1924. In the spring of 1924 a number of citrange stocks were budded to varieties of Satsuma oranges. These buds after starting suffered serious injury from the extremely dry hot weather of summer and failed to make satisfactory growth even when protected from the direct rays of the sun. It is believed that the young and tender growth of such plants can be more satisfactorily handled with the protection and shade offered by a lath house, and future work will be carried on under such conditions.

FIG. 12.—A 4-year-old citrangequat seedling at the seed farm, Sacaton, Ariz.

Two orange varieties, the Washington Navel and the Avery, the latter a seedling which originated in the Salt River Valley and is said to be hardier than the former, the Eureka lemon, and the Marsh grapefruit were also set out at the same time as the other plants. During the unusually low temperatures of the winter of 1919–20 the lemon trees were killed. The orange and grapefruit trees were rather severely frozen, but having recovered bore fruit for the first time in 1923. The fruit was slightly undersized, but of very good flavor and texture. In 1924 the grapefruit and Avery oranges bore light crops of excellent fruit. The Washington Navel trees set fruit, all of which, however, dropped off at the beginning of hot weather.

[19] This tree is from seed of the Thomasville citrangequat reported by W. T. Swingle and T. R. Robinson. Two important new types of citrous hybrids for the home garden—citrangequats and limequats. *In* Jour. Agr. Research, vol. 23, pp. 229–238, illus. 1923. It is very hardy, withstanding temperatures as low as 12° F., and the fruit, which ripens in October and November, is pleasantly acid and sufficiently sweet to be eaten out of hand. It is a very promising citrus fruit for regions where the winter temperatures are too low for varieties less hardy. It also offers promise as a stock for hardy varieties, such as the Satsuma orange and tangerine.

The results obtained thus far from the test of citrus plants would seem to indicate that in protected localities of the middle Gila Valley the production of the hardier varieties of these fruits may be successful. Hopes are held of demonstrating the particular value of such varieties as the Satsuma orange, the citrangequat, and the limequat.

DATES

The propagation and culture of dates is an important branch of the work at the station.

There are now at the field station 97 palms comprising 24 named varieties, and 200 seedlings. At the seed farm there are 36 palms of 16 varieties and two large bearing seedlings. Up to the present time the following varieties have fruited: Deglet Noor, Hayany, Rhars, Bayd Hammam, Kustawi, Zehedy, Kalara, and Koroch.

FIG. 13.—Date palms at the seed farm, Sacaton, Ariz., in 1925: Hayany (8 years old) at left, Deglet Noor at right, showing the method of boxing offshoots to induce rooting

Comparison of varieties.—As has been stated in a previous publication, the Deglet Noor variety is not well adapted to conditions at the field station, there being considerably more humidity during the fall than is desirable for the proper ripening of the fruit. A substantial part of the crop each year is lost through spoilage caused by excessive humidity. The seasons of 1923 and 1924 were exceptional in that much less of the fruit was damaged from this cause, although there was an almost equivalent loss from shriveling of the fruit through causes not yet fully determined. The fruit of this variety that reaches the stage where it may be ripened artificially, after being picked about half ripe, is placed in a tight electrically heated box and exposed to a temperature of about 95° F. for 24 to 72 hours. This completes the ripening processes started on the tree and produces a soft light-colored semitransparent date of fine flavor. Part of the fruit ripens on the tree but becomes so dry that it loses its value as a packing date, although still retaining its sweetness and flavor.

One of the Deglet Noor palms at the seed farm (fig. 13) fruited for the first time in 1923 and again in 1924, setting heavy crops both years. More than half of the fruit was removed early in each season, and the remaining bunches were given very careful attention and protection. As was expected, part of the fruit ripened naturally on the tree and proved to be of very good quality. It appears likely that this variety will do better under conditions such as exist at the seed farm, where the fall nights are slightly warmer and the summer temperatures a few degrees higher than at the field station, where the older palms are located.

The Hayany variety has fruited each year since 1922, both at the field station and the seed farm. This variety ripens earlier than the Deglet Noor and is therefore not subjected to the adverse conditions which the latter encounters. It has produced equally well in both locations.

The Rhars variety fruited very satisfactorily in 1923, but this date usually suffers from the same causes that affect the Deglet Noor and seldom produces a full crop in this locality.

The Saidy date of Egypt, of which a number of trees are growing both at the field station and at the seed farm, has not yet fruited; but, from its behavior under similar conditions in other date-growing regions of the Southwest, it is expected that this will be a highly valuable variety for local cultivation.

In 1924 a few ripe fruits of the Kustawi variety, a medium-sized golden-brown soft date of very good quality, were picked. Of the other varieties mentioned none have borne sufficiently to indicate their suitability or value.

Among the 98 seedlings that have fruited only a very few are of value. Most of them are either late-ripening sorts which do not mature their fruit or which crack and spoil when subjected to the relatively high humidity occurring in the fall. A few, however, are promising and may prove to be of value for distribution among the Indians. Several very promising male palms present in the planting produce each spring numerous bunches of pollen-laden flowers. These have been marked for future attention should propagation seem desirable.

Offshoot propagation.—Tests of the rooting of offshoots in various mediums, such as barnyard manure, peat, sand, and earth, in a canvas-covered shed have been made. The results from these experiments have not been satisfactory. By far the best success has been had by using the method of inducing rooting of the offshoots while still connected to the parent palm. Offshoots growing at the base of the palm and partly under ground send out roots naturally, but those higher up may be induced to root by placing earth-filled boxes around them and keeping the earth well moistened. Shoots rooted in this manner may be cut from the palm and transplanted with a minimum degree of loss and when transplanted make a more prompt and vigorous growth than those rooted after being removed from the parent palm.

Pollination experiment with dates.—In the spring of 1923 an experiment was conducted at the field station in an attempt to determine the length of the period during which pollination may be effective after the opening of the female flowers of the date. Fifty-seven clusters on nine different seedling palms were pollinated and data

recorded on nearly 19,000 flowers in determining the percentage of fertilization. Some time prior to the opening of the flower spathes they were carefully covered with specially designed bags of transparent paper which fitted rather closely and were made tight around the bottom. The time of the opening of the spathes was noted, and at intervals varying from 2 to 11 days thereafter the bags were removed and artificial pollination with fresh pollen performed. The method of application was with pieces of clean absorbent cotton heavily covered with pollen which were tied in place in the flower clusters. This permitted a greater uniformity in the quantity of pollen applied than would have been the case if the usual method of using sprigs of male flowers had been followed. It is extremely difficult in a closely planted area of date palms where wind-blown pollen is likely to be in the air, as was the case where this experiment was carried on, absolutely to prevent chance pollination of the flowers under observation, which naturally increases the probability of error. However, the results obtained indicate that the control of conditions was adequate to make the figures sufficiently accurate to show clearly that the longer the pollination is deferred after the opening of the female flowers the less likelihood there is of a good set of fruit being obtained. The highest percentage of fertilized flowers was 89.6, which was obtained on a cluster pollinated on the same day it opened; the lowest percentage, 7.2, was on a cluster where pollination was delayed 11 days, the longest period attempted.

Although in some instances a low percentage resulted where the delay was relatively short, in most cases where pollination was delayed four or more days there was a considerable reduction of the percentage of fertilized flowers, and as the period of delay increased this percentage decreased. Table 21 gives the average percentages of fertilized flowers obtained in this experiment.

TABLE 21.—*Percentage of date flowers fertilized in delayed artificial-pollination experiments at the United States Field Station, Sacaton, Ariz., in 1923*

Number of days delayed	Number of clusters pollinated	Percentage fertilized	Number of days delayed	Number of clusters pollinated	Percentage fertilized
0	3	73.6	7	5	59.2
2	1	89.0	8	7	46.0
3	1	83.0	9	6	35.3
4	6	70.0	10	4	26.3
5	6	65.7	11	2	23.2
6	5	54.3			

GRAPES

There has been a considerable extension of the area planted to grapes in the Salt and Gila River Valleys during the past two years. The early ripening of the Arizona Sultanina and Malaga varieties in advance of the California crop gives these an advantage in the eastern markets, and the profitable returns thus obtained have added impetus to the planting of grapes in this area.

The new planting of 20 varieties made at the field station in 1920 came into bearing in 1923, and these varieties serve to confirm the results obtained in the older planting. The Sultanina Rosea often

ripens as early as June 15 and can be depended upon for high production. The Sultana and the Malaga from Fresno, Calif., (fig. 14) are also heavy producers and well adapted to Arizona conditions. The Muscat Albardiens, Cornichon, Dattier, Mission, Purple Damascus, and Listan (*Golden Chasselas*) varieties, which performed well in the earlier plantings at Sacaton, are doing equally well in the new vineyard. In addition, the Black Malvoise, Monukka, Black Muscat, Chasselas de Neuchatel, Black Morocco, and Rose of Peru show promising results. The Black Malvoise and Chasselas de Neuchatel were found to be well adapted for jelly making. Another variety which has invariably ranked high in production is the Chavooche. It is inferior to the Malaga, however, as a fresh table grape.

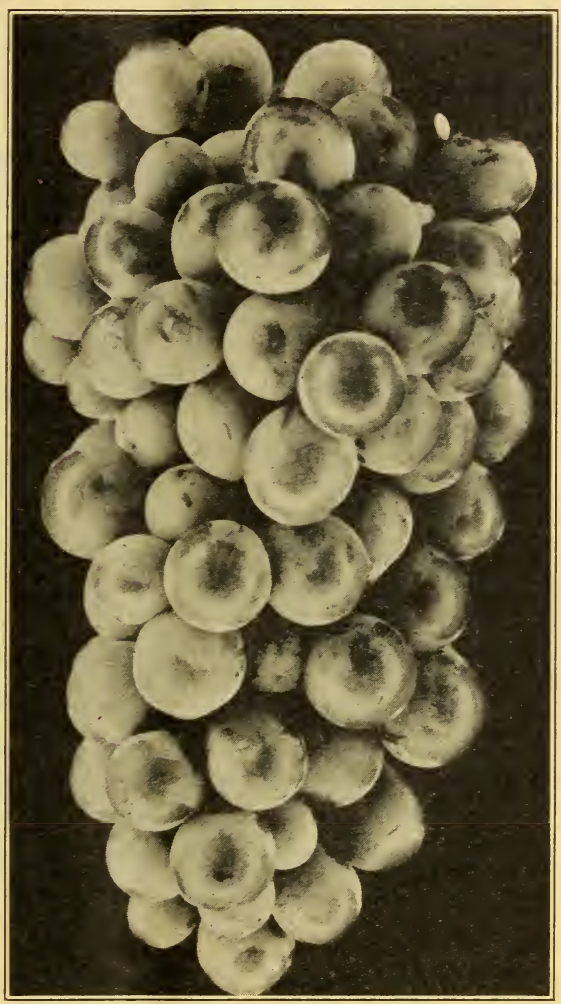

FIG. 14.—A bunch of Malaga grapes grown at the United States Field Station, Sacaton, Ariz.

A small experimental vineyard of 15 varieties was planted in 1920 at the seed farm and has borne some fruit for the past two years, but the vines are still too young to give conclusive evidence of their capacity to bear good crops on the type of soil where they are planted. The Malaga, Black Hamburg, Sultana, and Muscat appear to be the most promising. Some other varieties, such as Dattier, Chasselas de Fontainebleau, and Olivette Blanche, have fruited. These suffered during the first two years of their growth from the close proximity of a row of athel trees (*Tamarix aphylla* [20]). Since the removal of these trees the vines have made a substantial growth, and there is every reason to believe they will bear successfully.

[20] Formerly called *Tamarix articulata*.

PECANS

The satisfactory behavior of a few pecan trees which have survived from plantings made several years ago in the Salt River and Yuma Valleys of Arizona has given rise during the past two years to a considerable degree of exploitation in land investments and the sale of young trees in these valleys. About three carloads, or approximately 50,000 young trees, from other States were sold in the Salt River Valley during the winter of 1924–25, and large areas of land were planted to pecans as a result of the agitation of tree agents and a few realty dealers.

The planting of pecans at the field station was begun in 1908 and now comprises about 40 bearing trees representing 18 varieties. Some of these trees have been bearing for about 12 years; others have just begun to produce nuts. Although a few trees have shown no ill effects from the severe conditions of summer and have borne liberally, most of them have shown signs of distress and have been either shy or erratic in producing nuts. The nuts of some of the varieties are also below size, and many fail to ripen properly. However, a sufficient degree of success has been attained from this and some of the Salt River plantings to indicate that conservative plantings of some of the best varieties may be warranted to fill a need among the other horticultural crops of southern Arizona. The great number of young trees that have perished before getting started and the general behavior of those that have survived give no basis for the assumption that pecans will soon become one of the principal orchard commodities of this region.

During the last three years some of the younger trees at the station have come into bearing, among which were represented varieties that are being tested for the first time in Arizona. The Pabst, Frotscher, and Teche varieties produced nuts of high quality, but conclusions can not yet be drawn as to the bearing qualities of the trees. The Alley has so far proved superior to the other varieties in yield and ripening qualities.

A test planting of six varieties of pecans was made at the seed farm in 1919, but they appeared to be poorly adapted to the soil conditions and none of them survived after two years.

A record of the yield performances of some individual trees is given in Table 22.

TABLE 22.—*Comparative yield of dried pecan nuts at the United States Field Station, Sacaton, Ariz., for the years 1922, 1923, and 1924*

Field	Row	Tree	Variety	Yield per tree (pounds)		
				1922	1923	1924
D2	K	1	Alley	16.2	18.0	42.0
D2	I	10	Delmas	6.1	5.3	7.0
C2	K	10	Kincaid	5.6	8.3	14.3
C2	K	11	do	11.1	8.4	14.3
On ditch bank	I	1	do	5.4	21.5	2.0
C2	K	17	Georgia	10.2	15.3	25.5
D2	I	1	Stuart	1.0	2.0	7.5
C2	K	9	Texas Prolific	4.0	.5	3.0

ORNAMENTAL TREES AND SHRUBS

Numerous ornamental trees, shrubs, and vines have been planted at the seed farm in order to determine those that are best adapted for growth under the somewhat adverse conditions of soil and climate. It has been noted that some are well suited to the summer conditions but find the winter too rigorous, whereas with others the opposite is true. Among those which have been tested and found unsuitable may be mentioned the Monterey pine (*Pinus radiata*), wisteria (*Wisteria sinensis*), and cape-jasmine (*Gardenia florida*). All of

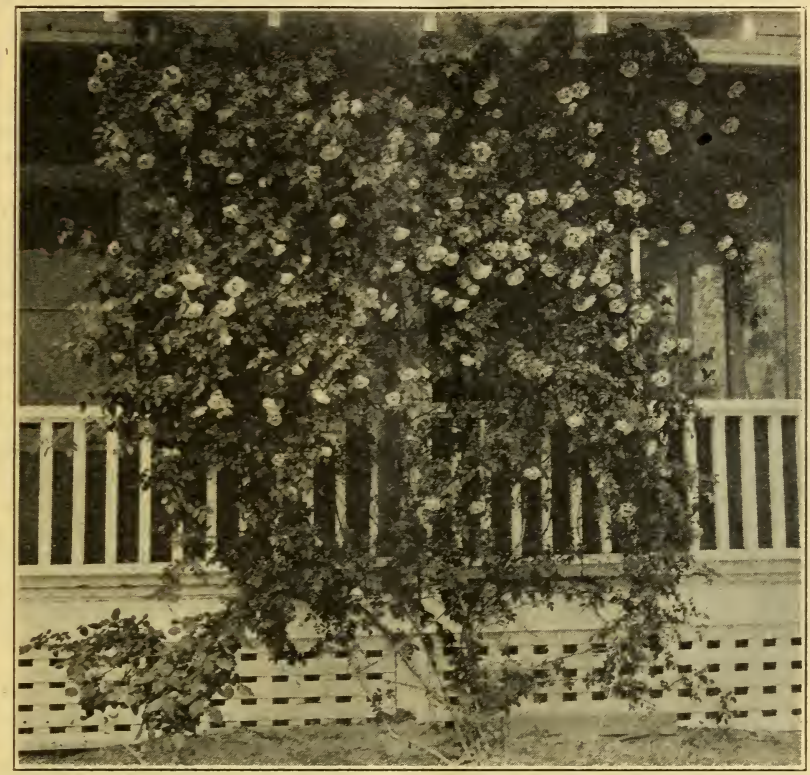

FIG. 15.—A Fortune Double Yellow (*Gold of Ophir*) climbing rose at the seed farm, Sacaton, Ariz.

these suffered from the extreme heat and aridity of the summer. Grevillea (*Grevillea thelemanniana*) grew successfully for three years, withstanding the usual winter temperatures, but it was killed during the extremely cold weather of the winter of 1919–20. This is a very beautiful flowering shrub, with feathery foliage and numerous brilliant scarlet flowers which are borne throughout most of the summer. It is possible that with adequate protection during the colder weather of the winter this plant may be grown successfully.

Roses have proved almost universally successful at the seed farm, making handsome bushes and bearing flowers most of the year. Among the best of these are the Sunburst, Etoile de France, Kaiserin Auguste Viktoria, and climbing Fortune Double Yellow (*Gold of*

Ophir; fig. 15). Other bushes which have proved well adapted are the oleander (*Nerium oleander*) and myrtle (*Myrtus communis*). For a climbing vine the balsam apple (*Momordica balsamina*) is particularly well suited, making a rapid and prolific growth when trellised and being highly ornamental with its bright-green foliage and brilliant orange-colored fruits.

Trees which have been tested and found well adapted are the Arizona cypress (*Cupressus arizonica*), southern magnolia (*Magnolia grandiflora*), Asiatic elm (*Ulmus pumila*), and the athel, or tamarix (*Tamarix aphylla*). The athel is a particularly fast grower and makes a beautiful evergreen tree suitable for planting in groups (fig. 16) or along roads. It is of special value as a windbreak, making a growth of 20 to 30 feet in three or four years, but it has been found that this tree has a great spread of surface roots which absorb the moisture from the soil to a considerable distance, interfering with the growing of other trees or crops near by. A row of these trees planted 25 feet from a small test vineyard made it almost impossible to keep the vines supplied with moisture and noticeably stunted the growth of those nearest it.

FIG. 16.—Group of athel (*Tamarix aphylla*) trees 3½ years old at the United States Field Station, Sacaton, Ariz., in 1923

The Mount Atlas pistache, or betoom (*Pistacia atlantica*), and the pistache (*P. vera;* fig. 17) are well suited to desert conditions and though not fast growers make particularly handsome shade trees.

A native tree which has great possibilities is the ironwood (*Olneya tesota*). This had been given special attention at the seed farm both as a hedge plant (fig. 18) and as an individual tree for avenue planting. Although slow of growth it can be made into a very handsome tree with proper care. Several fine specimens of considerable age are located around the cottage of the superintendent at the seed farm and are the most striking of the numerous ornamentals growing there. A curious fact about these trees is that when they receive regular and frequent irrigations they seldom blossom and bear fruit, but similar trees under desert conditions usually have a good crop of small brown beans each year.

In the spring of 1921 a small planting was made of seed of the so-called blue palm (*Glaucothea armata*). These were retarded somewhat in their early growth by the proximity of the row of athel trees, as

already described, but are now about 2 feet high and growing well. Two larger palms of the same kind, one of which is shown in Figure 19, together with two of *Erythea brandegei*, are planted near the

FIG. 17.—Trees of *Pistachia atlantica* (right) and *P. vera* (left) at the United States Field Station, Sacaton, Ariz., in 1924, showing the adaptation of these trees for shade and ornamental purposes in the semiarid regions

superintendent's cottage, and all are growing satisfactorily. As has been mentioned, the true date palm (*Phoenix dactylifera*) is being

FIG. 18.—Native ironwood (*Olneya tesota*) at the seed farm, Sacaton, Ariz., in 1923, pruned to heights of 2½ and 5 feet, showing its effectiveness as a hedge plant. Unpruned plants are shown at the left

propagated for fruit production. A few of these palms together with *Phoenix canariensis* are planted for ornamental purposes, for which both are admirably suited.

NURSERY OPERATIONS AT THE SEED FARM

In the spring of 1923 the propagation of pistache-nut trees was begun at the seed farm. The pistache nut, which is used principally

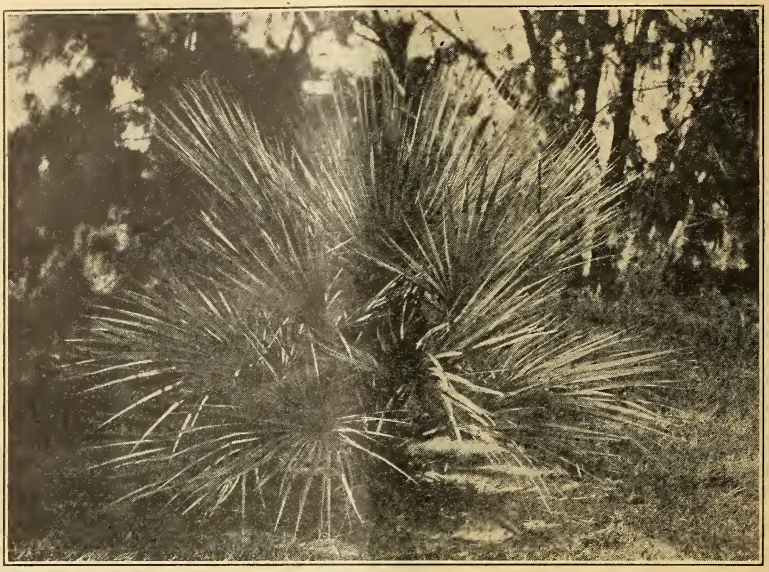

FIG. 19.—A blue palm (*Glaucothea armata*) growing at the seed farm, Sacaton, Ariz., in 1923

as a flavoring for confectionery, is the highest priced nut that reaches our markets. It is a native of the desert regions of Africa and Asia

FIG. 20.—Pistache nut, citrus, and fig trees in nursery form at the seed farm, Sacaton, Ariz., in 1924

and is at present being grown on a small scale in California. It is believed that this nut will be of considerable value for production in southern Arizona.

Young seedling plants of *Pistacia vera* and *P. atlantica* to the number of nearly 1,400 were received from the greenhouses of the Office of Crop Physiology and Breeding Investigations at Washington, D. C., and set out in nursery rows. In addition 500 larger plants of *P. chinensis* were received from nurseries in California. Most of the plants of *P. vera* were grown from seeds of Persian pistaches originated at Fresno, Calif. They have a valuable habit in that 100 per cent of the nuts crack naturally on the tree at the time of ripening, which is not generally true of other varieties of pistache. The *P. chinensis* and *P. atlantica* seedlings are chiefly valuable as stocks for grafting, the latter being especially drought resistant. (Fig. 20.)

In addition to the young plants set out, a bed of *Pistacia atlantica*, *P. chinensis*, *P. vera*, "self splitting," and *P. vera* hybrid seed was planted. Good germination was obtained from all except the *P. chinensis* seed, and several hundred plants were grown and transplanted to the nursery row the following spring.

Along with the pistache shipments from the Washington greenhouses, 105 small seedlings of *Pinus sabiniana* and *P. torreyana*—the former a nut-bearing species—were set out. These plants were rather small and tender, and there was a high mortality among them during the summer.

Of fig varieties, 130 cuttings of the Mission and Brown Turkey were set out in the nursery. They made a remarkably good growth during the season and were distributed among the Indians on the reservation in the spring of 1924, when a similar planting of cuttings was made to provide trees for further distribution.

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May 18, 1926

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